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Improving Science Teaching and Learning for New Teachers and Diverse Learners Using Participatory Action Research and Cogenerative Dialogue

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ABSTRACT

Conducted within the methodological framework of action research, this study examines the ways in which a beginning science teacher in a Korean elementary classroom engaged in collaborative research with her own students to resolve problems preventing effective science teaching and learning. Specifically, this study uses cogenerative dialogue between teachers and students to develop new teachers' knowledge of how to manage the classroom to be able to more effectively implement inquiry instructional strategies and knowledge of students as learners. Findings from this research suggest that by involving students in cogenerative dialogues, beginning teachers are provided with valuable insights into how elementary students think about school, science, and teaching and learning, which can help expand a beginning teacher's capacity to be an effective science teacher of science for all learners, especially diverse learners. These findings suggest that teacher education programs could better support beginning teachers by placing greater emphasis on how to conduct action research, including how to implement cogenerative dialogues to catalyze positive changes in their own classrooms. We conclude by discussing the important implications this research has for supporting new teachers struggle to effectively teach science and who would benefit from using strategies to foster improved relationships with their students and improved understanding about the challenges faced by diverse learners in their classroom.

Ⅰ. Introduction

The value of teaching science in the primary school is well established in the literature and many studies have demonstrated that students in the early years have a keen interest in learning science. However, student interest has been shown to decrease dramatically in the later elementary grades (Murphy & Beggs, 2003). This situation is often attributed to elementary teachers' lack of competence and confidence to teach science (Watters & Diezmannm, 2007). Indeed, many studies have found that new science teachers often lack academic preparation and/or experiences with science (Bianchini, Johnston, Oram, & Cavazos, 2003) and often have naïve beliefs about the nature of science (Abd-El-Khalick & Lederman, 2000). In addition, new teachers often experience a disconnect between their professed beliefs about the importance of using inquiry science teaching strategies and their tendency to focus on content transmission using traditional didactic teaching methods (Feiman-Nemser, 2010). These beliefs and practices can serve as obstacles to good science teaching aimed at preparing young children to be scientifically literate. Teachers' limited knowledge and negative beliefs and attitudes can have a significant impact on science learning outcomes for students, especially for diverse learners (Bianchini, *et al*., 2003; Park, Chu, & Martin, 2016). This is a concern for science teacher educators who need to prepare future teachers for inclusive classroom environments designed to support learning for culturally and linguistically diverse students.

Studies have found that beginning teachers, especially at the elementary levels, struggle to effectively manage students' varied science learning needs once in the classroom, especially when tasked with teaching science to diverse learners within in inclusive classroom settings (Hart & Lee, 2003; Killoran, Woronko, & Zaretsky, 2014). Novice teachers who lack the skills, knowledge, and experience necessary for coping with myriad challenges stemming from the need to understand content and curriculum, effectively plan and implement

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lessons, develop assessments to gauge student learning, and manage classroom behavior can be completely overwhelmed in the general education classroom (Casperson & Raaen, 2014). To support new teachers to be able to cope with these challenges, researchers have sought various ways to help teachers integrate theoretical knowledge and practical teaching experiences to be able to effectively facilitate all students' science learning. Many researchers are calling for teacher education programs are designed to help new teachers cultivate dispositions to take an inquiry stance with regards to their own learning about how to teach (Hammerness, Darling-Hammond, & Bransford, 2005). Specifically, teacher educators are calling for changes to the ways we prepare and support new teachers so they are better prepared to take control of their own learning by providing them with tools for analyzing their own teaching and make decisions based on student input about how to understand and handle complex situations in their class (Siry & Martin, 2014).

While it is a nearly universal practice to engage pre-service teachers in real classrooms for a teaching practicum, the amount of time spent teaching and the responsibilities teachers take on in varies widely from country to country and even program to program. In addition, teacher candidates often report their experiences working in real classrooms are at odds with what they learn about in university coursework (Yerrick & Hoving, 2003; Grossman, Hammerness, & McDonald, 2009). To improve new teachers' capacity to effectively teach science, teachers need to develop knowledge and strategies related not only to how to teach science content, but also how to reflect on their practice and transform the ways in which teachers view and interact with the students in their classrooms (Grossman, Hammerness, & McDonald, 2009). This requires changes be made in both the preparation of pre-service teachers and in efforts made to support beginning teachers following their appointment to their own classroom in the field. There is an emerging area of research focused on providing expanded field-based teaching practicum experiences for pre-service teachers in science that incorporate teacher-driven research, reflection on practice, and dialogue with collaborative teaching between teacher candidates and their students (Siry, 2011, Siry & Martin, 2014; Tobin & Roth, 2006). However, there are relatively few studies addressing teacher-driven research for improving new teachers' experiences in their own classrooms and there is limited research advocating for the involvement of young children, especially diverse students, in research aimed at improving their learning experiences. The existing research on how to support new teachers to teach science to culturally and linguistically diverse students is somewhat limited, but some studies have shown that teachers' inaccurate beliefs about language and low expectations about diverse students' abilities can negatively influence on students' science learning and achievement (Lee, 2004). Several studies (Brown, 2006; Wassell, Martin, & Scantlebury, 2013; Im & Martin, 2014) have found that teachers who appreciate the need to understand students' prior knowledge and experiences and who attempt to communicate and interact with students in culturally appropriate ways have the most success in teaching science to diverse learners. However, in order for teachers to be able to enact such strategies requires they have opportunities to acquire necessary knowledge and dispositions (Lee, Buxton, Lewis, & LeRoy, 2006).

In the last two decades, Korea's immigrant population has increased dramatically and has resulted in increased numbers of culturally and linguistically diverse students enrolling in public schools (Park, Chu, & Martin, 2016). Unfortunately, teacher preparation programs have failed to respond to these changes, so there are few requirements for coursework addressing multicultural education, Korean language learners, or inclusive education. In addition, during teaching practicum, there is no guarantee pre-service teachers will be placed in an inclusive classroom serving culturally and linguistically diverse students. Even if teachers are placed in inclusive classrooms, there is no guarantee the cooperating teacher would have sufficient knowledge and skills needed mentor teacher candidates to be able to effectively teach science to diverse learners. As a result of these limitations, many new teachers' may find themselves in a situation where they are expected to teach diverse learners even when they have limited knowledge about how to do so. Novice teachers facing such challenges are likely to be working in isolation from peers and have limited access resources to meet their needs. However, new teachers have access to a critical resource that we believe is chronically under-utilized: their students. In this paper, we advocate for employing participatory action research and cogenerative dialogues as tools to support new teachers' to expand their knowledge about students' learning needs, which can inform instructional decision-making and support students to better facilitate their own learning.

Research seeking to engage students as co-researchers with teachers is not prevalent in the literature, especially at the elementary levels where adults tend not to perceive young children as being capable of sharing important insights or contributions. However, some researchers argue the potential for engaging educators and students in dialogue aimed at transforming pedagogical decision-making. For example, researchers in science education (Tobin, Seiler, & Elmesky, 2005; Stith & Roth, 2008) have advocated for teachers and students to engage in participatory action research involving cogenerative dialogue as a means to democratize knowledge production and to foster opportunities for empowerment by teachers and students in their own classrooms. Seiler and Elmesky (2007) found that involving students as co-researchers using cogenerative dialogue enabled them to be responsible for helping to identify issues to be resolved, to collect and analyze data, and to make recommendations about how to change teacher practices to benefit students' learning. In this paper, we share findings from a study in which a new teacher engaged elementary students from her own class in participatory action

research that incorporated cogenerative dialogues. The following research questions framing our investigation are:

1. How can engaging in participatory action research and cogenerative dialogue with students improve new teachers' instructional practices in the science classroom?
2. How does engaging in cogenerative dialogues with students improve new teachers' knowledge and understanding about how to better support students as science learners?

In answering these questions, we demonstrate that utilizing action research and cogenerative dialogue can expand Korean teachers' professional awareness and understanding about how children experience school and science. We argue this can lead to improved pedagogical practices that may be beneficial for improving learning outcomes and achievement for culturally and linguistically diverse students who are often marginalized in schools due to the lack the social spaces needed to create positive relationships with teachers and peers. We conclude by advocating the need for teacher educators and researchers to help new teachers develop their capacity to engage in classroom-based research that can support their continual growth and professional development as teachers of all students.

II. Theoretical Framing

In this study, participatory action research and cogenerative dialogue serve as a theoretical and methodological framework for conducting inquiry into the challenges facing new teachers and their students in science classrooms. In this section we first describe the theory underpinning these tools and in the following section we discuss how we used these tools to direct participant interaction, data generation, and collection.

1. Participatory Action Research

Participatory action research is similar to traditional notions of action research in that participants engage in systemic inquiry to gather information about how people teach and learn (Mills, 2011). Traditionally, action research focused solely on inquiries, reflections, and change in action implemented by the classroom teacher. However, participatory action research expands this circle of reflection by expanding roles and responsibilities to include other stakeholders, including students, administrators, and even parents. However, engaging students as co-collaborators in participatory research necessitates teachers and students take a democratic approach to dialogue that welcomes and supports critical and dissenting opinions (Bergold & Thomas, 2012). This distinctive feature of participatory research means that knowledge production should lead to new insights for all participants, not only teachers. This is because participatory action research is an orientation to inquiry that shifts the emphasis from action and change to collaborative research activities with a distinct focus on planning and conducting research with people, rather than on people. In this regard, participatory action research is well aligned for use with cogenerative dialogue, which also places emphasis on reflecting on practices with others.

2. Cogenerative Dialogue

Cogenerative dialogues have been proven to be an effective method for structuring interactions between teachers and students in ways that benefit co-participatory research. Cogenerative dialogue (LaVan, 2006; LaVan & Beers, 2005; Roth & Tobin, 2001; Wassell, 2004) is a discussion between stakeholders that examines shared events and experiences. Cogenerative dialogues can occur in both formal and informal settings and usually involve the teacher and 1-6 students and generally take place either before/after class, but can also take place during instructional time between a teacher and the entire class of students during or after instructional periods. Research has shown that through repeated cogenerative dialogues, teachers and students learn how to explain their perspectives and choices. These conversations among participants are crucial in raising consciousness about different participant perspectives, providing a means of addressing social reproduction by examining sites for both successful and failed interactions which can then be transformed to improve teaching and learning (Martin, 2006). Shared perspectives can be used to inform the emerging understandings of classroom interactions, the quality of these interactions, participant practices and how these patterns of interactions contribute to the accomplishment of the collective activity of teaching and learning science.

Guba and Lincoln's (1989) authenticity criteria provide the theoretical underpinning for cogenerative dialogues. Table 1 introduces each of the four criteria as characterized by previous research (Martin, 2006). These criteria are used to ensure that research be ethical and beneficial to all participants. In using these criteria to structure dialogue, participants are agreeing that participants agree to engage in dialogue that is both ontological and educative, meaning that participants aims to acknowledge and understand how each person views the world without necessarily trying to change any one's perspective. A critical component of both participatory action research and cogenerative dialogue is that participants should actively seek to identify problems and to catalyze change. Ensuring that cogenerative dialogues are catalytic requires that participants accept individual and collective responsibility to enact changes in their practices to affect positive changes. Finally, dialogue should consider tactical authenticity issues by ensuring that participants by working to help participants who are unable to help themselves. This speaks to the need to consider both individual and collective needs and to take care not to disadvantage participants.

Table 1. Authenticity Criteria Informing Cogenerative Dialogue

Criteria	Meaning	In Practice
Ontology	Share your own perspective	Teachers need to invite a diverse student to volunteer to participate.
Educative	Learn from perspectives of others	Everyone has the right to speak, but no individual voice is privileged.
Catalytic	Strive to make positive changes	All dialogue should be driven by the need to make positive changes in teaching and learning
Tactical	Assist all individuals to benefit from the research	Participants have a responsibility to ensure that changes do not disadvantage any members.

Ⅲ. Methodological Considerations

This research stems from a larger qualitative study examining the potential for engaging science teachers and students in their classrooms in research and dialogue about science teaching and learning in an effort to improve instruction and academic achievement for all students, but especially for culturally and linguistically diverse students. Multiple teachers and students in different schools enrolled in the project and agreed to engage their students in participatory action research. Changmi and her students implemented the action research cycles and cogenerative dialogues without direct participation from Sonya (see Park, 2013). For the purposes of this paper, we first offer a general overview to describe the method by which participants engaged in action research and cogenerative dialogues. Then we describe how the authors collected and analyzed the data associated with these activities to answer the research questions presented in this paper.

1. Methodological Overview for Conducting Action Research and Cogenerative Dialogue

In this study, the stages associated with both action research and cogenerative dialogues both serves as methodological guidelines for engaging teachers and students to generate data. Both participatory action research and cogenerative dialogue necessitate the involvement of teachers and students as co-participants in findings ways to improve the shared learning environment. In addition, both require cyclical implementation of a set of practices designed to have participants identify and describe problems, generate and analyze data, plan and implement changes in practice in order to resolve identified issues, and then continually review and re-evaluate the impact of any changes. Figure 1 describes the general process of used to drive the participatory action research activities between the teacher and her students.

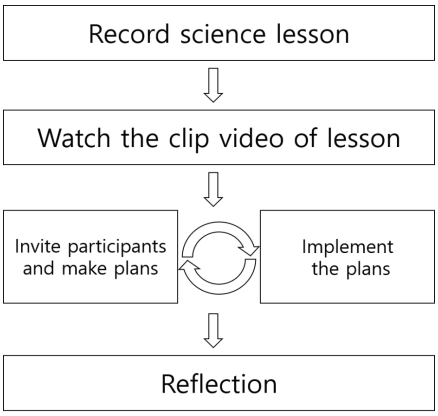

Figure 1. Overview of participatory action research cycle

Figure 2 provides an overview of the process for engaging participants in cogenerative dialogue. During these discussions, the authenticity criteria were used to structure dialogue. Short video vignettes captured and edited by the teacher from the science lessons were shown to students and offered all participants a starting point for asking questions about how to improve science teaching and learning in their classroom.

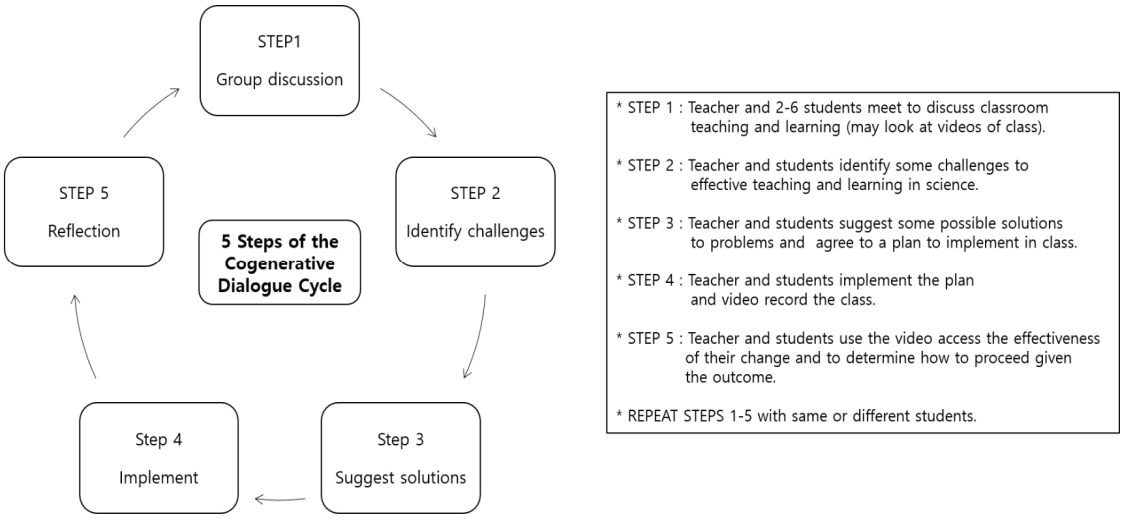

Figure 2. Overview of cogenerative dialogue cycle

The goal of each cogenerative dialogue was to have teachers and students reflect on practices in their own classroom with the intent of identifying "positive practices" and "negative practices." Positive practices are identified with a goal of increasing the frequency with which these practices are implemented. Negative practices are discussed and participants co-generate a plan for trying to alter the practice and try something new. At the end of each cogenerative dialogue, teachers and students agreed on a "co-generated" plan for changing their practices by implementing new actions in an upcoming science lesson. To evaluate the effectiveness of the change in practices, the new science lessons was then recorded, edited, examined and re-evaluated by the same participants during a follow-up cogenerative dialogue. In the follow-up cogenerative dialogue (Step 5), the participants evaluated the effectiveness of the changes and decided how to proceed. This cycle is repeated over and over as needed.

2. Research Context

This study took place in a fifth grade science classes in a public elementary school that has been designated as an "Education Welfare-Special Invested" school since 2009. Eligibility for this designation is determined by the number of the students receiving basic living subsidies and the number of students coming from multicultural families (defined as a family where one or both of the parents are not Korean). Schools can designate a portion of their budget to support students to attend field trips, enroll in after-school programs, take psychological aptitude tests, and to speak with professional counselors.

2.1 Participants

This research was conducted with 25 students, 16 boys and 9 girls, who each agreed to participate in the project. All parents consented to allow their children to participate in the research. One student, whose mother was Japanese, was identified as a multicultural student. Students had lower than average performance in science. Science was taught three times a week and normally took place in the classroom or in a special laboratory room. Changmi was the homeroom teacher for these students and taught almost all subjects. Students in this school had 22 class periods of instruction each week and each lesson was 40 minutes.

Changmi was the teacher participant in this study and was a first-year elementary school teacher. She held a bachelor's degree in elementary education and was pursuing a master degree in science education at the time the research was conducted. Changmi was interested in implementing action research in her classroom to support her to be an effective teacher for the students in the class. Sonya served as a critical friend and academic supervisor for Changmi. This study engaged both researchers and students in data analysis and interpretation. While Changmi collected the majority of the data from the school site, both authors conducted classroom observations and recorded video data.

2.2 Ethical consideration

As this study involved direct contact with minors, the Institutional Review Board (IRB) of Seoul National University monitored all procedures, including teacher and parental consent and student assent processes and data collection. The authors provided all required documentation from all parents and their children prior to start of the study and the researchers orally explained all ethical issues to the student participants before commencing the study. In accordance with guidelines for conducting ethical research, the authors use pseudonyms for the name of the school and for all participants in the study.

3. Data Collection and Data Sources

As reported above, Changmi and her students engaged in a participatory action research project using cogenerative dialogues with a goal of improving science teaching and learning. In this section, we report how we as researchers used the data generated from their investigations to identify and evaluate how this research impacted on Changmi's perceptions about her students as science learners and how this informed her instructional decisions in the science classroom.

All data was collected over a 15-week period and included extensive video and audio recordings capturing science lessons, laboratory activities, and cogenerative dialogues. Videos were captured using either hand-held or stationary cameras to record teacher and students from varying positions within the classroom depending on the particular activities and questions that needed to be answered that day. In the following section, we provide additional details about each data source. A total of 28 lessons were videotaped or audiotaped resulting in about 56 hours of raw classroom data. Additionally, three whole-class cogenerative dialogues, three small-group cogenerative dialogues, and two one-on-one cogenerative dialogues were recorded for a total of eight. In addition to video recording, many of the cogenerative dialogues were audiotaped by placing a recorder with a flat microphone on the desk in the center of a group of students. Both authors kept detailed field notes to provide additional details about classroom observations, reactions, and questions. To gain more perspectives from students about their experiences in the classroom, each student was encouraged to keep their own research notebook and to write short reflections about each lesson and ideas or suggestions they had for improving class.

4. Data Analysis and Interpretation

In this paper, we will share data excerpted from the participatory action research project to provide evidence of the ways in which this process of engaging in research with students provided Changmi an improved understanding of her students as individual science learners. Using excerpts from videos of classroom interactions, transcripts of student and teacher dialogue, reflections of field notes, and artifacts generated from student work, we demonstrate how this approach to participatory action research supported Changmi to make changes to her teaching practice. We provide evidence that documents changes in instructional practices during laboratory activities that served to address both academic and social needs of her students. We trace these changes using the both the steps of the action research cycle and the authenticity criteria to provide examples of how these tools can help new teachers identify problems, collect information and share perspectives with students, cogenerate and implement solutions, and then reflect on the outcomes of these changes.

Ⅳ. Findings and Discussions

This section has been divided into two sections. Using offprints from the videos, field notes, and transcripts from interactions during class and cogenerative dialogues, we provide episodic events from the classroom to demonstrate the ways in which Changmi's participation in this research with her students enabled her to gain an improved understanding of how her students experienced science teaching and learning. We share these to provide some insights into the kinds of things new teachers could learn about their students from using this approach in their own classrooms. We then provide examples of the ways in which she and her students catalyzed changes in their practices in attempts to improve instruction and learning.

Question 1: How can engaging in participatory action research and cogenerative dialogue with students improve new teachers' instructional practices in the science classroom?

In this section, we organize findings using the authenticity criteria to demonstrate what Changmi was able to share with her students about her goals for the research and what she learned from students by analyzing and discussing videos with students during cogenerative dialogues. We first introduce data that demonstrates the process and offers evidence of student and teacher participation in the research and cogenerative dialogues.

1. Participatory Action Research : Identifying Issues for Closer Examination

As way of introduction to the overall research aims and goals to students, Changmi first explained her to students that she was involved in a project focused on improving her own teaching and she wanted to invite students to participate with her.

> CM: I am doing research to improve my teaching and I realized that your thoughts and opinions are the most important in improving our class. We—you and I—need to work together. So I suggest doing research together to improve our science teaching and learning. I am convinced that we can make positive changes through this research.

To engage students in the research, she first provided them all with new research notebooks and asked students to write some general ideas about what they felt needed improving. An initial analysis of student feedback about the class indicated four general areas of concern (Table 2).

Table 2. Problems students identified about science class

Content	Number of student answers (% of student answers)
Classroom management	12 (48%)
Instructional principles	8 (32%)
Learners and learning	3 (12%)
Other	2 (8%)

After categorizing the comments, Changmi found that the majority of students were concerned about classroom management issues that negatively impacted on science learning. Their comments reflected her concerns about the high noise level, lack of student preparation before class, and the disruption caused by having multiple students leave their seats to walk around class during instructional time. Before asking her students' opinion about issues that disrupted learning, she did not anticipate they would notice these kinds of things. With regards to instructional strategies, she found that several students had suggestions about the need to change the distribution of laboratory materials during experiments. The current method required a lot of time and prevented students from being able to equitably participate in the experiment. Changmi decided to invite students to volunteer to attend a cogenerative dialogue to discuss the results of their collective feedback.

2. Cogenerative Dialogue : Sharing Perspectives

A total of seven students volunteered to meet for the first cogenerative dialogue to discuss the results of the whole-class feedback. Desks were arranged in a group to enable all participants

to see one another and to be heard. The meeting took place during a 15-minute break in regular instruction time while other students were at recess. A total of four boys and three girls participated and they represented a mix of both high achievers and low achievers. After introducing the authenticity criteria to describe the purpose and structure of cogenerative dialogues, Changmi asked students to share their thoughts about issues negatively impacting on science teaching and learning.

After agreeing that the noise level during experiments was the most pressing issue, the students and Changmi began to identify what kinds of problems the noise caused for their learning and to begin to cogenerate potential strategies that could be used to minimize the noise.

EK: When the teacher scolds a student, the other students have to wait until teacher stops and time goes on.
CM: Oh, this must be an important point. When I point out to students and warn them about the bad behavior, I wasn't thinking about the other students waiting for me to finish. Do you have any good idea to solve this problem?
EK: How about using sticker system in our science class? Give the students who show the behavior stickers, like a yellow card [warning system used in sports like soccer], instead of talking such a long time. And when they get three stickers, they have to do the extra work for our class.
DI: Dancing in front of the class?
HS: No, then we will keep laughing and we would waste our learning time.

By the end of the meeting, Changmi and the students developed a clear description of how to implement a new instructional strategy designed to reduce the amount of time taken from class to scold individual students. The goal of this meeting was to develop a new practice that could catalyze a change during science class, which would improve instructional opportunities for more students.

When asked to suggest any other issues that the group could try to address, a student checked her research notebook and shared that the chaotic method used for distributing lab materials at the start of an experiment made it difficult for her to concentrate on the activity. While reading from her notebook she noted that

When the teacher gives us the materials, some of the students are standing up and talking each other. I think it would be better and the students would be quieter if the materials were ready before class. (Sonya's research notebook excerpt).

Using video captured from a laboratory activity, Changmi analyzed what generally happened at the start of each class and found that she and her students appeared to be very flustered while handing out and receiving materials. Students were standing up and moving everywhere and the video revealed that several students asked questions about the materials and the lab, but Changmi could not even hear them above the noise (Figure 3).

Figure 3. Commencement of lab showing the class in chaos while receiving materials

Changmi and her students reflected on the situation and determined that the noise level and uncontrolled movement of materials and students was not only disruptive for her teaching and their learning, but was also potentially dangerous because a student could easily have tripped and broken a glass or spilled chemicals on someone. Following a brief discussion, Changmi suggested she would try to prepare the materials before class for each group and then ask one student from each group to come up to the front to receive their materials while all other students remained seated.

3. Participatory Action Research : Implementing a Change in Practice

At the beginning of class on the following day, Changmi and students who participated in the cogenerative dialogue introduced to the whole class their suggestion for a new practice to be implemented in an effort to help manage student's behaviors during science class. All students were asked to consider the suggestion and to decide as a group whether to implement this change. When introducing the new strategy, students helped to clarify by re-stating the rules or giving examples that had been discussed during the cogenerative dialogue. The system was designed to provide rewards for collective positive behavior for students engaged in collaborative group work using green stickers and to warn individual students within groups by awarding red stickers for behaviors that disrupted the class. Students were allowed three reminders using the red sticker before receiving demerit in the form of a yellow sticker. Students reasoned that this system helped to provide individuals with visible warnings about their behavior without disadvantaging the entire class for each disruption. To help distribute responsibility for ensuring positive behaviors within small groups, the students decided that if an individual received a yellow sticker, the small group to which the students belonged would lose one green sticker (See Figure 4).

After each science class, the students added up the number of rewards gained by their group and then placed green rewards stickers next to their individual names on a chart that was hanging on the wall. Each week, students could exchange green stickers for small

Figure 4. Author 1 introducing reward system and describing strategy for encouraging individual and collective responsibility for decreasing noise levels during science laboratories.

gifts like stickers, erasers, and pencils. In addition, students could also receive award stickers by raising their hands to answer questions, paying attention, actively working with peers, and being "on task" during science class. Students reasoned that this small incentive could both help to reduce disruptive behaviors and promote behaviors that made science class more productive for all students. By focusing attention on individuals, Changmi and her students attempted to give responsibility to individuals for changing their behavior, but by also connecting the reward system to their groups, they also tried to emphasize the need for all students to be responsible for improving the science learning environment.

4. Cogenerative Dialogue : Reflecting on and Evaluating Change

After implementing the new system during several class periods, Changmi and her students held a second small group cogenerative dialogue to evaluate how the change had affected individual students' behavior and whether that change was improving their collective ability to engage in science lab activities without too much noise and chaos.

CM: We have had several classes since applying our new rule in class. How was it? Please share your thoughts.

JW: I think the sticker system is working. Students are quieter than before.

MH: Yes, the stickers. They were good because students think about the presents [rewards] they can get with stickers.

WB: But sometimes the sticker system made us even noisier.

CM: Really? Why do you think like that?

WB: When you give students green reward stickers [for positive behaviors], students try harder to raise their hands [which is noisier]. But sometimes when we students get a yellow card, we blame each other and argue about that.

JW: Yes, sometimes it feels like the sticker system doesn't work.

CM: For me, it was much easier to teach actually. However, I felt I was quite busy teaching and putting stickers on the board at the same time. And also when I put up the yellow sticker, I could see your faces becoming angry. And I'm a little bit worried about my ability [to apply the system fairly] because I can't see all of you at the same time to help check your behavior. So I guess we think the sticker system works in some ways, but not in other ways. Let's think about this system more.

Following this discussion, the students indicated that sometimes receiving a demerit sticker it made the students in their group lose concentration on the lesson and they felt embarrassed in front of the whole class. Changmi also expanded on her concern that she could not accurately and consistently apply the system. To try to address these issues, the students made an adjustment to the rules by adding a "back-up system" whereby the teacher would share responsibility for assigning warnings with group leaders. Each group leader evaluated the behavior of their group members during class and they were able to warn their group members two times before writing down that student's name to turn into Changmi. Using this system, a student would then receive a yellow card only for that lesson. When some students expressed concern about ability for group leaders to fairly implement their responsibilities, the students voted to implement a "double checking system" where group leaders would check the behaviors of members using the small group check sheet. Before turning in this list, students were asked to engage their group in a member checking activity to make sure that the group members all agreed about their recommendation to the teacher.

In addition, Changmi indicated she would take notes in her research notebook to crosscheck the identity of students who did not engage in the science class and who those who made unnecessary disruptions. After determining who had received yellow cards, it was agreed that Changmi would speak individually with those students about their behavior rather than scolding the student in front of the whole class. Using this method, group members took on the role of warning their peers to modify their behavior and more widely distributed responsibility for implementing the system to all students in the class. Reflection on allowed for modifications that made the system more suitable and provided more time for Changmi to work engage small groups of students discussion about the laboratory activities rather than spending so much time and energy managing student behaviors.

Discussion Point 1: Increased Instructional Time and Improved Understanding of Students as Learners

Analysis of video showed that after implementing the reward system, there was a significant change in the quantity and quality of teacher. Before implementing the system, utterances not related to the content of the lesson accounted for 6-8 minutes of a 40-minute class period. As a result, students routinely lost 15-20% of the time allotted for conducting science experiments for non-instructional teacher talk. Additionally, changes made regarding the method for distributing laboratory materials also saved time and resulted in fewer students being out of their seats (See Figure 5).

Figure 5. Material box in each group

Analysis of video showed that because all students had access to all lab materials from the beginning of the period, Changmi could direct students' attention to the materials and provide directions for doing the lab while actually examining the materials. Prior to making these changes, some students had not even received their materials before the directions had been explained. This meant that not all students were familiar with the lab equipment and would be at a disadvantage from the start of the lab. When reflecting on the changes seen in the video during a follow-up cogenerative dialogue, students commented on the improvement this method had regarding their ability to remain organized and focused.

HS: When you had to go to the front and get the materials yourself, it was really disorganized. The students from the group farthest from the teacher's desk had to go very far before. But now, we don't have to do that . . . so . . . so . . .
JY: It's very convenient.
HS: Yes, it's very convenient.
JW: Last time, we brought the materials with us from teacher's desk to our desk. But now, since all materials are in the basket all together, it's much more . . . more . . .
CM: Safe
JW: Yes, safe.

As a result of these changes to the instructional practices during science class, Changmi found she was able to focus more on teaching science rather than on managing the students. She found that these changes allowed her to concentrate more on teaching science and provided her students more time to actually engage in the activities. Video analysis of the laboratory utilizing both methods showed that the class was less noisy, more organized, and students were on task without needing verbal reminders. A comparison of videos from before and after the changes show Changmi engaging in more science related talk and meeting with students individually to help move them along in the activities. Through cogenerative dialogue, students and teachers can discuss power relationships and the roles of participants (Seiler, 2002) as well as consider individual and collective activity, goals, roles, equity issues, curriculum, and responsibility. The notion of shared responsibility is central to these discussions, as participants reflect on shared experiences, power relationships, and the differing roles and perspectives of all those involved (Martin, 2006). These small changes provided her more opportunities to engage students in science discourse which could allow her more insights into how students understood the concepts they were discussing. In addition, this provided her with more opportunities for positive interactions with students under less stressful circumstances. Instead of admonishing students, she was able to build relationships by holding conversations with students while walking around the classroom.

Question 2. How does engaging in cogenerative dialogues with students improve new teachers' knowledge and understanding about how to better support students as science learners?

In this section, we organize findings to demonstrate how Changmi's use of cogenerative dialogues with her students expanded her knowledge about and understanding of her students, which enabled her to make improved decisions about how to support students' learning and assessment more effectively. In addition, we demonstrate how Changmi's on-going engagement in dialogue with her students and the changes they implemented as a result of their participatory action research projects supported her to develop improved relationships with her students. By improving her social interactions with students, we argue she and her students we more open to trying new strategies that resulted in improved learning opportunities for students and increased science achievement. Using excerpts from data collected as part of the action research and cogenerative dialogues, we share evidence demonstrating how changes in teacher-student social relationship positively impacted on science teaching and learning, especially for a multicultural student who was struggling in the class.

1. Transformation of Teacher-Student Interactions

Prior to commencing the participatory action research project and cogenerative dialogues, video of the classroom shows Changmi had few one-on-one interactions with students for either instructional purposes or for social discussion. Almost all dialogue was either directed to the whole class or in front of the whole class. Generally, when a student misbehaved, Changmi would publicly chastise the student by raising her voice, calling out the student by name, and drawing everyone's attention to the problem. This practice generally succeeded in stopping the behavior and redirecting the student towards the learning goals. However, for one student, YoonSung (pseudonym), this type of interaction could lead to an escalation of negative and disruptive behaviors that took time from instruction for all students and negatively impacted YoonSung's participation in class.

Below we share a vignette excerpted from video captured during a laboratory experiment that demonstrates a critical change in the way Changmi approached behavior management as a result of the positive relationship she had been developing with YoonSung during formal cogenerative dialogues outside of class. We selected this example relationship because it demonstrates not only an improved social outcome for Changmi and her student, but also an improved academic outcome for YoonSung. Video shows a lively whole-class discussion during a laboratory activity in which Changmi is trying to engage members of different groups to share their observations. YoonSung appears unable to sit still as he swivels in his chair tapping his pencil and hands on the desk while talking to his classmate while Changmi is trying to elicit a response from a different group. Her voice filled with frustration, Changmi suddenly calls out YoonSung's name and chastises him in front of the whole class for talking, being off task, and distracting his neighbors. Immediately this action results in his silence, but it also resulted in his disengagement from the whole-class discussion and his withdrawal from participation in his group activities (See Figure 6). Prior to this interaction, YoonSung could be seen answering questions as part of the whole-class call and response and he had raised his hand multiple times to offer his individual answers.

Figure 6. YoonSung is non-responsive during whole class interaction after being publicly chastised

Changmi noticed that YoonSung (pseudonym) was no longer participating in class. When reflecting on the video after class, she reported that while this had occurred numerous times before her involvement in the participatory action research, she found that now that she developed a relationship with YoonSung during cogenerative dialogues outside of class, she felt badly that he was not participating. Before when these kinds of interactions occurred, she had simply felt relieved he was no longer disrupting the class. She now valued and recognized the positive contributions YoonSung generally made to his group and she wanted him to re-engage in the lesson. So during the class break, she decided to have an impromptu one-on-one cogenerative dialogue with him to discuss what had happened and to cogenerate some plan for moving forward in a more positive way. The following screenshot (Figure 7) was captured during this discussion.

Figure 7. One-on-one informal cogenerative dialogue huddle

The offprint shows Changmi engaging in an informal cogenerative dialogue "huddle" with a student. Huddles have been described in previous research (Martin, 2006; Martin, 2009) as brief encounters that take place between participants during class time as a result of practices developed while engaging in formal cogenerative dialogues outside of class. Audio captured from the huddle reveals Changmi asking YoonSung to tell her what was happening and letting him know she was disappointed by his disruption of her lecture. YoonSung responded, saying

> YS: Actually, it wasn't what you thought. I wasn't chatting with the group members. Hun-Joo was not doing any writing at all so I told him to do something. I was trying to help him but he wasn't listening at me. So I kept trying to get him to do some writing.

Changmi concluded by saying she appreciated that YoonSung was trying to support her classmate and that she apologized for misunderstanding and not taking the time to learn what was happening before yelling at him in class and she let him know that she would work with Hun-Joo to engage him more effectively so that YoonSung did not need to try and manage this situation. She also asked if YoonSung had any other problems with his team and suggested that if they do, she and his team should try to solve the issue together. The whole interaction took about 30 seconds. An offprint taken (See Figure 8) after the huddle shows YoonSung's immediate transformation and was evidence of the positive affect Changmi could have when seeking dialogue with her students.

Reflecting on this interaction after class, Changmi noted that had she not stopped to speak with YoonSung, she believed he would have continued to be disruptive and non-engaged. She acknowledged that the method of publically chastising students was particularly ineffective for YoonSung because the embarrassment caused him to withdraw from learning. Analysis of lessons captured following this incident show Changmi rarely chastised students in public again. Rather she utilized the reward sticker system or engaged in one-on-one huddles with students to address the issue.

Figure 8. YoonSung's participation after the informal cogenerative dialogue huddle

2. Deeper Understanding of Students Means Better Opportunities to Teach

In this vignette, we describe how engaging in participatory action research and cogenerative dialogue with students provided Changmi with both a framework for tackling problems and the social space needed to develop relationships with students that provided her with increased opportunities to learn about the difficulties her students faced both inside and outside of science class. Of particular concern for this study is the potential for this approach to expand new teachers' awareness and capacity for supporting diverse learners. Changmi especially wanted to find ways to support Doo-Hee, a student from a multicultural family who was also identified as having special education needs. Specifically Doo-Hee could not read or write well in Korean well. He lacked fine motor skills comparable to his peers, had difficulty spelling simple words, and struggled to read unfamiliar text. As a result of his limited literacy ability he had difficulties in all subjects. Although he participated very actively in science class activities, when it was time to write about his experiences in his science notebook, he failed to provide any answers and simply stared at his notebook. To help cogenerate a solution to his problems based on Doo-Hee's own feedback, Changmi decided to engage him in a series of formal one-on-one cogenerative dialogues outside of class. From these conversations, Changmi was able to gain a broader understanding about his challenges in the home and at school from which she was able to develop more effective strategies to support him as a science learner.

As part of her solo teacher action research project in the previous semester, Changmi had worked to develop modified worksheets for Doo-Hee to provide him more structure to allow him to complete his assignments. The worksheets had fewer problems, used easier vocabulary, and contained more visuals and diagrams. When Doo-Hee was first presented with the modified worksheet, he did not say anything, but he completed his work for the first time in the school year. Instead of remaining silent during the whole discussions about the concepts covered in the worksheets, he spoke with other students about his answers. The following is an audio transcript from the one-on-one cogenerative dialogue between Doo-Hee and Changmi in which she asked him what other kinds of changes he could suggest to help Changmi improve his science worksheets.

CM: I see you enjoying the science class.
DH: Yes, it's fun.
CM: But I don't see you filling in the blanks in the workbook or writing down your thoughts in your inquiry notebook. Can you tell me why?
DH: [silence].
CM: Learning science is as important as enjoying science. Since you're enjoying the experiments very much, I think you are already ready to learn science. I would like to help you with writing. Is it hard for you?
DH: Yes, a little bit.
CM: Then, do you remember the worksheets that I provided you last semester? [The worksheet] had easier words [on it, but] with similar meanings. Shall I make another one for you?
DH: [silence].
CM: You can say whatever you want. It will be much easier for me to help you if you say your feelings honestly.
DH: I want to do the same thing as others.
CM: Oh, I didn't know that. Thanks for telling me. Then what is your biggest need when you do the same work with your friends?
DH: Words [vocabulary].
CM: Okay, then I'll help you to more easily understand the words you're having problems with. Will that be better for you?
DH: Yes.

Reflecting on their conversation afterwards, Changmi acknowledged that she was hurt to learn that the modified worksheets she had spent so much time and effort to create were not appreciated by Doo-Hee. Instead, he wanted to have the same worksheet as his classmates. When thinking about why he would prefer to have a worksheet, which he could not complete, rather than the modified worksheet, Changmi recalled the comments of Doo-Hee's peers who had seen his special worksheet and complained they wanted "easier work." Changmi then recognized how her unilateral decision to make a modified worksheet without discussing it with Doo-Hee could have made him embarrassed and she also acknowledged that when she had heard these comments she had not addressed them and had also failed to consider how their comments affected Doo-Hee. This discussion made clear for Changmi the limits of traditional action research as opposed to participatory action research.

As a teacher, Changmi felt she had to find ways to help Doo-Hee overcome the social stigma associated with making accommodations for his learning because when she made changes, he was able to complete his assignments and express his understanding of the material. This was important for his conceptual understanding and his academic progress. In an attempt to support Doo-Hee without

drawing too much unwanted attention, Changmi suggested that during class, she would try to be physically closer to him when students were doing any writing in the science class and that she would orally discuss the instructions for the assignment and explain the assignments using easier vocabulary. Doo-Hee agreed to this arrangement and the two decided to re-assess the outcome in a follow-up cogenerative dialogue after trying out the new strategy.

The following offprint was captured from video from the next science lesson reveal Doo-Hee being unable to begin the activity prior to Changmi's oral explanation. At first, Doo-Hee can be seen playing with his inquiry notebook while his classmates were writing in their notebooks. After verbally repeating the instructions using modified vocabulary and using gestures to show Doo-Hee what he was being asked to do, he began to attempt the assignment. The second offprint shows Doo-Hee writing in his workbook, but after a brief huddle, Doo-Hee decided it was too difficult so Changmi suggested an alternative assignment of answering some questions in his workbook. The third offprint shows a close-up of Doo-Hee's completed workbook assignment with all answers correct (See Figure 9).

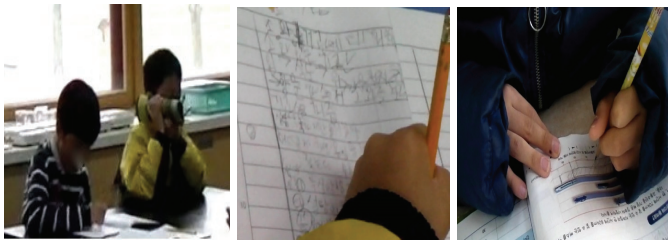

Figure 9. Changes in Doo-Hee's participation as a result of supports provided by Author 1 during class.

Supporting Doo-Hee to try to improve his participation in writing activities required consistent attention from Changmi during class and required on-going encouragement during discussions in cogenerative dialogues. Video analysis of subsequent classes during the semester showed Doo-Hee consistently remaining engaged and on task in science class, even during writing time. Unexpectedly, Changmi found that Doo-Hee's peers began trying to help him complete his writing assignments during class. Video shows students sounding out words for him to spell, showing him their own notebooks, and making corrections to misspelled words. When asked to reflect on how he felt about these changes, Doo-Hee wrote

> I can enjoy science more. I want to study science with my teacher again. (Doo-Hee research notebook)

While these small efforts resulted in some positive changes for Doo-Hee during science class, Changmi found that there were limits to what she was able to do to support him. When trying to interpret his writing, Changmi often had to guess his intent, as she could not easily read what he had written. She found that Doo-Hee also had trouble organizing and expressing his thoughts orally so that whenever Changmi called on him to share his ideas in whole-class discussion, she needed to re-state what he said in order for him to be understood by his peers. In an attempt to try and address these issues she encouraged him attend additional lessons to improve his Korean reading, writing, and speaking after class.

While working to organize these after-school lessons, Changmi was referred to the school counselor who worked with Doo-Hee using play-psychotherapy once a week. The counselor informed Changmi that Doo-Hee was in very unstable emotional state and he had great difficulty controlling his anger. She learned that Doo-Hee, his two brothers, and his mother faced lived in an abusive home. Doo-Hee's mother was Japanese and had a strained relationship with the father due to his physical abuse and lack of financial support. To provide for living expenses for herself and her three boys, Doo-Hee's mother worked a 24-hour shift every other day. This meant that even on the days when she was home, she was too exhausted to take care of her sons. As a result, they often woke up late, missed breakfast, and were late coming to school. During the site visit, Doo-Hee's mother reported that her husband often hit her mother and physically and verbally abused Doo-Hee, calling him his "most stupid son." During the home visit, Changmi found Doo-Hee's mother had strong Korean oral fluency, but she was not literate in reading and writing so she was unable to help her sons with their school assignments. Following the home visit with the school social worker, Changmi wrote

> I have a feeling of helplessness after seeing with my own eyes [his living situation]. I feel there's nothing much more I can do for this poor child (Changmi, field note observation)

This visit made more clear to Changmi why Doo-Hee may have so many difficulties in school as they challenges he faced in his home life could negatively affect his ability to perform well in school and in science. Doo-Hee and his siblings had limited academic support and home, he was often hungry at school and teased by his peers for eating several portions of the school lunch, and his clothes often appeared unwashed and wrinkled. These issues stemming from his home life affected his social interactions with his peers and impacted on his ability to learn and be successful in school. This was a critical lesson for Changmi to learn in her first year as a new teacher.

Discussion Point 2: Decreased Sense of Isolation and Appreciation of Limits

When Changmi first began this research, she knew she needed to transform her teaching practices, but she did not anticipate that she would be able to do so with the help of her students. As a first year teachers, she was used to struggling alone to try to solve her

problems. Learning how to share responsibility for student behavior, rather than being solely responsible for "controlling" student behavior was one of the most important things she learned from her research. She reflected on this, noting that before this research

> When I taught lessons I thought I'm in control or I *should* control students. However, during this research, I have grown to realize that students could help me and help their peers to improve science teaching and learning. I am not isolated. I have my students who can help me. I learned that students could be resource for my learning, if I provide them opportunities to share their ideas with me. (Changmi research notebook)

By engaging in problem solving with her students and being open to dialogue to discuss issues that are not typically addressed in the science classroom, Changmi felt she gained a better understanding of her students as individuals and she felt she was learning how to build productive relationships with my students that allowed her to improve how she manages the learning environment. By adhering to rules that structure how participants talk to one another, cogenerative dialogue provides participants a neutral social space in which to examine conscious and unconscious beliefs and practices that affect teaching and learning in the classroom. Students have years of knowledge to draw from based on their own experiences in classrooms. If teachers support students to critically reflect upon what they know about how to improve teaching and learning, teachers can capitalize on students as a resource for knowledge and as collaborators who are also invested in making positive changes to the learning environment.

However, Changmi also realized there were limits to what she and her students could accomplish on their own. Changmi reflected on what she learned after visiting Doo-Hee's home, stating

> When I visited his home I had intended to be able to talk with his parents about the issues Doo-Hee faced in our science class. However, I quickly came to realization that a student's life involves more than my 40-minute class and that there are some things that I cannot change. Although it made me feel hopeless, I was compelled to try to adhere to the tactical authenticity criteria that structured our research and dialogues. I wanted to try to do something to help him from within the realm of the school. (Changmi, field note observation)

Changmi decided to apply to be Doo-Hee's homeroom teacher for the following school year in an effort to give him continued support. However, school policy requires students have a different homeroom teacher every year so they can experience new environments and to avoid discrimination and favoritism. So, she was not able to support him as she had intended, but she did reach out to Doo-Hee's new teacher to let her know about his situation and to describe the strategies she had been using and the positive impact they had on his writing and participation in science class.

Changmi felt that her coursework and teaching practicum did not provide her the skills she needed to address this kind of situation, or to even consider it. Many studies have reported teacher candidates find their experiences working in real classrooms to be at odds with what they learned about in their university coursework and with what they experienced in their teaching practicum (Yerrick & Hoving, 2003; Grossman, Hammerness, & McDonald, 2009). Prior to engaging in this research and developing a personal relationship with Doo-Hee through cogenerative dialogues, Changmi reported she had never thought beyond the planning her lessons and teaching science. She believes that this experience helped her to understand that in order to meet the social and academic needs of her students inside the classroom, she need to learn more about my students outside of the classroom. By expanding the circle of people involved in supporting students, Changmi found she could better support her students both inside and outside of the classroom. This experience radically changed how she viewed both her responsibility to her students as a teacher and also the possibility that there would be real limits to what she could do to support her students to learn.

V. Conclusions and Implications

In this paper, we examined data from the perspective of a beginning science teacher and researcher to consider what impact these changes in classroom practices had on Changmi's science teaching and on students' science learning. By comparing video from classes recorded before and after the start of the participatory action research project and the cogenerative dialogues, we identified two important findings. First, we noted that making changes in teaching practices based on student feedback during cogenerative dialogues resulted in an increase in the instructional time available for engaging students in inquiry activities. These changes in teaching practices meant that Changmi had increased opportunities to engage with learners in small group and one-on-one interactions during activities so she had more chances to consider what students were learning from their activities. The positive relationships being developed during formal cogenerative dialogues became a resource for supporting Changmi to engage students in informal one-on-one huddles during class to address behavioral issues and learning problems. This resulted in few whole-class disruptions and helped sustain individual students' science learning opportunities. Second, as a result of her participation in this research, Changmi felt less isolated in her attempts to solve problems. As a result, she began to see both her students and other teaching professionals within the school as resources for improving teaching and learning. This supported Changmi to re-evaluate her role as a science teacher to consider the responsibilities she had to her students beyond teaching subject matter. This helped to re-position Changmi as a professional

rather than a struggling first year teacher who sought out supports to catalyze changes when she realized the limits of what she could do alone.

This study suggests a critical point about the need to re-structure teacher education programs in Korea to place more emphasis on how to provide pre-service teachers with both the knowledge and experiences they will need to be able to effectively solve challenges they will undoubtedly face as beginning teachers. Specifically, this research supports the need to prepare new teachers to be able to conduct action research in their own classrooms and to be introduced to cogenerative dialogue as tools that will expand beginning teachers' ability to continue to develop their professional practice in the first few years of their teaching. These tools are not only valuable for beginning teachers, but also for veteran teachers who want to improve the teaching and learning in their classroom. In addition, we believe they could support school administrators to address problems at the school-wide level to improve the teaching and learning environment at more systemic levels by engaging parents and communities in more productive partnerships to address challenges faced by both sides as they struggle to support their children to be successful in school. Korean researchers and teacher educators may take away from this research the need to reform current teacher education programs to consider how to more effectively engage pre-service teachers in the practical experiences needed to develop knowledge not only about content but also about how to continue to learn and develop as a new teacher by engaging in participatory action research with students and peers.

For a teacher to be successful as an educator, they need to be able to draw from a diverse pool of knowledge and strategies to engage their students, manage their interactions while implementing effective pedagogical strategies, and support students to construct conceptual understandings about specific content. Unfortunately, pre-service teachers have limited chances to develop knowledge, skills, and strategies needed while in their teacher education programs and during their teaching practicum experiences. Once these students become beginning teachers, they find themselves isolated in their teaching, spending time only with their students and having limited opportunities to engage in professional development with peers. As a result, many beginning teachers find that they themselves have to solve their own problems, often resorting to trial and error tactics because they were not educated about how to engage in research on their own practice in an effort to catalyze positive change. If we want teachers to be successful in using inquiry, argumentation or other student-centered instructional strategies, then we have to provide them tools for accessing and understand the social dynamics in the classroom so they can effectively facilitate the interactions between students and their peers. Today many science education reforms focus on engaging students in constructing science knowledge and meaning from collaborative interactions. For teachers to meet this challenge, they need to understand their learners, but typical classrooms offer teachers and students few opportunities to learn about one another or develop the trust and relationships necessary for students to feel comfortable to actively engage in group-focused tasks. Cogenerative dialogues offer teachers and students a social space to develop their relationships, build trust with one another, and facilitate and maintain positive interactions in the learning environment.

In addition, while Changmi and her students' focused much of the inquiries and discussions around how to address classroom management issues and finding ways to improve instructional strategies, it was not until these issues were addressed that they could shift their attention to addressing science teaching and learning. Cogenerative dialogue allowed Changmi and students opportunities build positive social relationships that allowed them to take risks with one another and try new teaching and learning strategies that improved science achievement student and teacher enjoyment. Engaging in participatory research and cogenerative dialogues with students does not offer new teachers a panacea for addressing and resolving all problems, but it does offer them structures to support collaborative inquiry into how to approach a problem and offers a community of people and their collective knowledge and experiences to think about it. This may be important for new teachers who can be overwhelmed by the many challenges they face in the beginning years of their careers. Although teacher attrition has not been significant problem in Korea's educational context, high levels of attrition rates for beginning teachers have been documented in many international educational contexts (Fantilli & McDougall, 2009). For example, in some urban districts in the United States, researchers have found about one-half of all new teachers exited the teacher profession within the first five years of their career (Ingersoll & Smith, 2003). The ability for schools and districts to retain new teachers in the profession can be influenced by the level and quality of support they receive as part of new teacher induction or mentorship programs (Darling-Hammond, 2003; Joiner & Edwards, 2008).

Finally, for science educators concerned about equity issues, inviting students to critique unequal social relations in society and in science can be an important first step in having diverse students question and create new and different representations of school and science that are more inclusive of their own interests and concerns (Moore, 2007). Engaging students in dialogue about school and science provides teachers a greater capacity for building bridges between home and school experiences and being able to draw from instructional strategies that are better connected to students' learning preferences. However, choosing to involve students as co-participants in action research necessitates that teachers be willing to move the locus of attention from themselves to the larger community. bell hooks (1994) argued that engaging students in democratic dialogue allows students to facilitate their own learning by involving themselves in real work issues within their own context. This requires

that teachers see themselves as active learners who can co-construct understanding about what is happening in their classroom with their students (Naidu, 2014). An important goal of cogenerative dialogue is to take an approach to teaching and learning that is situational and responsive to issues in the local context. When teachers choose to engage students in cogenerative dialogue, they are inviting students to engage in their own learning as a stakeholder who has the potential to effect change in how school and science is experienced by the learner. We see this issue as being key for the professional development of new teachers as we believe that by engaging in participatory action research using cogenerative dialogues with students, novice teachers can develop an improved understanding of their students as learners which can help inform teachers' decision making regarding other aspects of their instructional practice. Cogenerative dialogue coupled with participatory action research has the potential help teachers be able to develop more inclusive learning environments that can support all students to learn science. As the student population becomes more diverse in terms of students' language and cultural backgrounds and students' ability, providing teachers the tools they need to be responsive to a diverse range of learners' needs will become more necessary. Additionally, research and policy aimed at supporting teachers to become more reflexive about the need for changes in their own practice is also needed. We believe this study offers a useful and adaptable method that can empower teachers to expand opportunities for students' to develop academically and socially in school contexts.

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