
Title	Enabling classroom change by infusing cogen and coteaching in participatory action research
Author(s)	Tang Wee Teo, Mohamed Faizal Bin Badron and Aik-Ling Tan
Source	<i>Asia-Pacific Science Education</i> , 3(1), 6-26
Published by	SpringerOpen

Copyright © 2017 The Authors

This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0>).

Citation: Teo, T. W., Mohamed Faizal Bin Badron, & Tan, A. L. (2017). Enabling classroom change by infusing cogen and coteaching in participatory action research. *Asia-Pacific Science Education*, 3(1), 6-26. <http://dx.doi.org/10.1186/s41029-017-0019-7>

The final publication is also available at Springer via <https://apse-journal.springeropen.com/track/pdf/10.1186/s41029-017-0019-7?site=apse-journal.springeropen.com>

ORIGINAL RESEARCH ARTICLE

Open Access



Enabling classroom change by infusing cogen and coteaching in participatory action research

Tang Wee Teo ^{*} , Mohamed Faizal Bin Badron and Aik-Ling Tan

* Correspondence:
tangwee.teo@nie.edu.sg
National Institute of Education,
Natural Sciences and Science
Education (academic group),
Nanyang Technological University, 1
Nanyang Walk NIE7-03-83,
Singapore 637616, Singapore

Abstract

Participatory action research is an empowering approach to advance research *with* participants. This paper describes and discusses the process and outcomes in engaging cogenerative dialogue (cogen) and coteaching in participatory action research (PAR) to support science curriculum change in a Singapore lower track classroom. The intervention was introduced after researching in a science teacher's two lower tracker classrooms for about 18 months and observing that his lessons were teacher-centered and he experienced difficulty engaging the students. Using the empirical findings to inform teaching practice, the researchers engaged the science teacher and two selected students in two cogen sessions to identify issues with the science lessons. The students suggested solutions which were taken up and used to plan and design revised lessons co-taught by the science teacher and one researcher. This paper describes changes to the teacher's and researcher's teaching, learning, and research experiences through the lens of cogen and PAR. Transcripts from one cogen session, one cotaught lesson, one teacher interview, and one researcher's written reflections were analyzed to distil affordances of PAR that led to changes in the classroom practices, views about science teaching and ways to carry out science research. The study illuminates the potentially transformative role of cogen, when coupled with action research, in Singapore and other classrooms.

Keywords: Participatory action research, Coteaching, Cogenerative dialogue, Transformative education, Singapore

Genesis of a cogen- and coteaching-infused PAR

Action research in Singapore dates back to 1998 with the launch of the *Teachers Network* charged to develop a fraternity of reflective practitioners (Salleh, 2006). Following that period and especially after 2003, more action research projects, conferences, and seminars were organized by different stakeholders in education (e.g., schools). However, efforts in action research were fraught with challenges as the projects may be initiated by school leaders rather than teachers, there is insufficient time to complete the research due to high teacher workload, and there is a lack of support from researchers who can guide teachers in understanding the theoretical underpinnings of action research (Salleh, 2006). Following the last point, is the emergence of a derivative of action research done *with* teachers and researchers known as participatory action research (PAR). A Google

Scholar search on PAR in Singapore yielded no results, suggesting that PAR has either not *yet* been carried out, researched upon or reported.

This paper is drawn from a larger study about lower track science classrooms in Singapore. Here, we report on a small exploratory effort—combining PAR, cogenerative dialogue (cogen), and coteaching—to engage a teacher, Kenny (pseudonym), in rethinking about alternative ways to teach students in the lower track classroom. While cogen has been well-reported in the science education literature for more than a decade, it has not been reported in studies conducted in Singaporean classroom contexts. There are many possible reasons for this. For example, it is difficult to arrange for students, teachers, and researchers to meet for cogen because the school timetable is usually very packed, and teachers have many teaching hours and other responsibilities outside the classroom. Additionally, it is less common for teachers to *work with* students to improve on classroom teaching as this is usually done through obtaining feedback from other more experienced teachers in peer mentoring programs and hence, students are seldom consulted on their views about the teaching. As such, our cogen effort can be regarded as an inaugural and bold attempt to co-share the responsibility of making classroom change in a tripartite (teacher-student-researcher) relationship. Through the enacted experience of doing cogen, Kenny and Faizal (the second author of this paper) reflected and/or changed their practices, and the researchers learned how to implement cogen more effectively in their future work.

In the 18 months prior to the enactment of cogen, we observed that the majority of Kenny's lessons, including those in the science laboratory, were teacher-centered. Despite having a teacher aide in the classroom who helped in classroom management, Kenny was gradually losing control of this class as evident through the increased frequency of his interjected "Shh" within a spoken sentence and the gradual increase in the volume of his voice to overpower the classroom noise. Kenny confessed during an interview that he was better at teaching higher track and graduating science classes because the students were more focused. Kenny was, however, very eager to obtain feedback from the researchers so that he could improve his teaching in the lower track science classroom. He had, however, never solicited direct feedback from students about his science teaching. Instead of sharing with him our single-sided interpretations of his teaching, we thought that it would be appropriate to include the voices of his students. We decided to have Kenny hear from the students and have an open conversation with them about issues that they observed from their experiences as students, rather than conducting student interviews and sharing retrospective or processed information with the teacher. To create this platform for open discussion that can potentially lead to change in practice, we decided to adopt cogen, as informed by our readings of Tobin's work (2006, 2014).

We do not claim to be experts in cogen as it was also our first experience in trying out cogen. To understand what is cogen and ways to go about doing it, we arranged for a workshop for ourselves and Kenny. The workshop was conducted by our research consultant who is an expert in cogen. At the end of the first cogen session, Faizal volunteered to assist Kenny when the latter expressed his need for support in making lesson change. This was the genesis of the cogen- and coteaching-infused PAR cycle.

At the time of the study, Faizal had recently left his school to teach in a local teacher education institute and had just started on his part-time doctoral program. He was

interested to use cogen in his own research study so this current study provided a first exploratory experience for him in doing cogen. Prior to joining the institute, he was a science teacher for 7 years in a middle school. As he was familiar with the science syllabus and content that the teacher was teaching in the lower track classroom, he offered to work with the teacher in planning, designing, and coteaching the subsequent lesson. The other researcher, Tang Wee (first author), is a faculty member of the same teacher education institute. Her main role in the study was to plan and facilitate the cogen. Essentially, the main beneficiaries of the cogen- and coteaching-infused PAR were Kenny and Faizal. This paper discusses the challenges they faced, considerations they gave, insights gained from doing cogen and coteaching, and how these informed their own views, practice, and/or research work.

In what follows, we discuss the literature of PAR and cogen, and coteaching. Based on the literature, we describe a PAR model that infuses cogen and coteaching. This model also shows our research design which we will elaborate in greater detail in the methods section.

Participatory action research (PAR)

Participatory Action Research (PAR) is a form of action research often associated with social transformation involving participants from various organizations, communities, industries and corporations (Creswell, Hanson, Clark Plano, & Morales, 2007). The research participants share a common social situation and through PAR, seek to improve the social situation. Kemmis and McTaggart (2005) highlighted seven key features of PAR. PAR is (1) a social process; (2) participatory; (3) practical and collaborative; (4) emancipatory; (5) critical; (6) reflexive and (7) transformative.

First, the social interaction in PAR shapes and reshapes the role of the participants. For example, when a preservice teacher teams up with an experienced teacher to work on the instructional strategies in the classroom, there is a continuous change in role and identity of the preservice and experienced teacher as they progress in the study.

Second, PAR is participatory. This is the essence of advancing research *with* the participants rather than *on* the participants (Heron & Reason, 2001). Using the previous example, the preservice and experienced teachers can analyze videos of their own teaching to have a better understanding of the impact on student learning. In doing so, the participants are reviewing their own actions and making the necessary steps towards change.

Third, PAR is practical and collaborative. PAR is practical because the outcome of the research is to improve the social situation of the participants involved in it. This is achieved through working together and exploring new ways of reducing irrational, unproductive and unjust interactions in the structure of a social organization. PAR is emancipatory and aims to empower the participants from the constraints of irrational, unproductive and unjust social structures to make changes to improve their social situation. Based on the example given on the first two features of PAR, if students are included in the research, they are given the opportunity to comment on the teaching approaches of the teacher. It is emancipatory because the students have the social interaction power to provide feedback to their teachers who are predominantly regarded as the authority figure. This is also linked to the fourth feature of PAR, which is being critical. For example, when students provide critical feedback to teachers, the

comments may invoke rethinking of the curriculum. This allows transformation in teaching approaches that improve the learning situation of students.

Fifth, PAR is reflexive and aims to bring about change in practices through the reiterative process of reflection and action. Last, PAR sets out to transform both theory and practice by exploring different perspectives contributed by the participants. For example, as the participants consider and explore the different perspectives and ideas, they are collectively being reflexive until a potential solution emerges that helps to improve the social situation. The present study is a PAR as Kenny and the researchers actively engaged in the research process, responded to the issues raised by students, implemented real and constructive changes in the classroom, and reflected on the changes that would inform future actions.

Cogenerative dialogue (cogen)

The role of dialogue between teacher and students can be extended to discuss pertinent issues that prohibit learning from taking place in the classroom, in the form of cogen. Cogen is a structured discourse involving stakeholders that share a common experience, (LaVan, 2004; Roth & Tobin, 2001). The main stakeholders are usually the students, subject teachers and researchers. The explicit goal of engaging in cogen is to “catalyze change” (Martin, 2006, p.702) for the purpose of improving teaching and learning praxis in the classroom (Stith & Roth, 2010). The process of engaging in cogen can be elucidated into two stages. The first stage requires the stakeholders to identify pertinent issues that inhibit the process of teaching and learning. This is done by analyzing videotaped lessons individually or collectively and selecting vignettes from the recorded lessons for further discussion. The chosen vignettes may depict pertinent issues such as teacher’s instructional practices (Siry & Martin, 2014), students’ learning difficulties (Im & Martin, 2015), and desired learning behavior (Martin, 2006; Tobin, 2006). The second stage requires the collaborative effort of the stakeholders to cogenerate a workable solution to address the pertinent issue(s) identified in stage one. The cogenerated solution is a shared consensus and all stakeholders are responsible for the transformative change in the classroom and sustaining it (Martin, 2006).

Cogen is more than just having a conversation. Cogen entails discussions based upon the shared experiences of the people involved (Roth & Tobin, 2001). Each person will critically discuss the shared event (Tobin & Roth, 2006). The social and cultural context of the topic under discussion is considered (Roth & Tobin, 2001). In cogen, the process requires the people to be on equal footing in terms of power level during discussions (Tobin & Roth, 2005). No one voice is more significant than the other. This suggests that doing cogen necessitates the re-defining of roles of the people involved to ensure collective responsibility (Tobin & Roth, 2002; Ritchie, Mackay, & Rigano, 2006). This can potentially translate to better rapport, trust, respect and relationship between the people (Im & Martin, 2015). Clearly, cogen contrasts with the usual teacher-student classroom talk. One of the key differences is the collaborative process in generating solutions for the topic that both the teacher and students identified as an issue or problem of concern to them.

Despite the many advantages of cogen, we are aware that it may not be successfully carried out in our research context. Drawing upon our lesson observations in more than 120 lessons in eight Singapore lower track classrooms in the larger study, we have

observed the imbalanced power relationship between teachers and students as evidenced by the relatively high percentage of teacher-dominated classroom talk, and time spent on controlling the student behaviors. Our interviews with the teachers who taught these classes also illuminated strong deficit views about students (e.g., student motivation, attitudes, abilities). Such deficit practices and mindset that positioned students as “the problem” could inhibit teachers from considering students as resource persons who they could *work with* to resolve problems. However, this did not deter us from trying out cogen and studying its affordances to teachers and researchers in the Singapore context. Cognizant that the full potential of cogen may not be realized given the circumstantial conditions, the changes made in teaching and learning may not be completely “transformative”.

Integrating cogen in PAR

There are commonalities between the features of PAR and the features of cogen dialogues, which make them suitable to be integrated in a study. In this section, we explain the rationale for infusing cogen within the PAR framework. We discuss the literature for studies that have infused cogen and PAR and the changes that took place.

Wassell and LaVan (2009) commented that cogen is an evolution of PAR. To begin with, both PAR and cogen studies involved social practices. The participants involved in PAR and cogen interact with one another to seek change to a social situation. For cogen in education, the social context of interest is mainly the events that are unfolding in classrooms such as teaching practices, learning practices or mediating student behavior. The social context in PAR studies may involve participants from different organizations and looking at social contexts that have a wider impact to the community.

A study by Siry (2011) demonstrated another feature of PAR: the continuous shaping and reshaping of the participants' roles as they engaged in cogen and coteaching. Siry conducted a study with six preservice teachers and 25 children in third grade with their science teacher. She found that having the preservice teachers engaged in cogen with the experienced science teacher provided support in the preservice teachers' classroom praxis. This was evident when one of the preservice teachers, who was teaching for the first time, found herself stuck when she directed an unfamiliar question to the children. As the experienced teacher was aware of the preservice teacher's plan since they cogenerated it together, the former could step in without undermining the latter's position as the class teacher and helped the children to reexamine the question in a different perspective. The shaping and reshaping of the role of the experienced teacher was captured seamlessly as she stepped in to provide support for the preservice teacher and stepped out once the preservice teacher was able to continue with the lesson.

The participatory feature of PAR is visible in the cogen study by Martin (2006). The study involved the researcher as the teacher, and a student named Jamie. Martin was concerned about the way Jamie behaved in her chemistry lesson. Jamie was timid, self-conscious and needed constant encouragement to perform in chemistry. This was a stark contrast from how Jamie behaved during basketball practices. She was the team captain, well-respected, confident and determined athlete. When Martin invited Jamie for a cogen session, she learned that Jamie displayed insecurities during her lessons because she was unsure of her answers and constantly sought to validate her answers from her peers. This was different in Jamie's position as a team captain. She knew

exactly what to do and played the game right. The participatory feature of PAR was visible when Martin began to learn about Jamie's insecurities through cogen. She was able to have a better understanding of her own teaching practices and made Jamie felt more at ease and relax during her lessons.

The practical and collaborative features of PAR were infused in a study by Roth and Tobin (2010). The study involved a resident teacher named Alex, a beginning teacher named Chris and 24 high school chemistry students for a year. They found that having Alex and Chris engaged in cogen enabled the two teachers to align their teaching resources together. This provided additional support for Chris since it was his first-year teaching chemistry. The high level of collaboration between both teachers resulted in them aligning, subconsciously, their instructional habits. In short, there were evidences that Chris began to imitate the way Alex conducted his lessons by repeating certain words such as "very-very" in a similar intonation as Alex when he was trying to emphasize important points.

The emancipatory feature of PAR transpired from a study by Im and Martin (2015). The purpose of the study was to allow the teachers to have a better understanding of students' learning behavior. The study involved a fifth grader named Isaac, newly migrated from Korea. His science teacher was Jane and Ben was his English teacher. Ben's role is to support Jane and Isaac during science lessons. Ben initially perceived Isaac's learning behavior of writing the science concepts in Korean as a sign that he needed help in interpreting what Jane said during lessons. As such, Ben began to re-explain the concept taught by Jane in English without realizing that Isaac has understood the content delivered. The PAR features of emancipatory and critical were clearly visible when Isaac was empowered to liberate himself from the constraints of the social situation he faced in the classroom and expressed his irritation towards Ben's approach. The reflexive and transformative features of PAR also transpired within the same study. After being aware of how his approach has caused irritation in Isaac, Ben provided him with more space and time to conceptualize his learning points in Korean before attempting to explain or translate the content in English. This resulted in a transformation in the support Ben provided for Isaac.

In summary, the literatures reviewed in this section involved cogen that embodied features of PAR. Based upon the review, we argue that infusing cogen into the PAR framework is seamless since both approaches involve shared ownership (Kemmis & McTaggart, 2005) and the exploration of multiple perspectives geared towards change in practice.

Faizal as the focus of the study

We used cogen to identify one or a few common issues of concern to teachers and their students (main stakeholders in classroom teaching and learning). Figure 1 below illustrates how this was done in our study.

The focus of this study is to describe the experience of a teacher-turned-researcher, Faizal, as he participated in cogen with four other participants (the science teacher, two students, and a co-researcher). At the time of the study, Faizal was a part-time doctoral student and full-time lecturer at a university that provided teacher education programs. Having former school science teaching experience, he

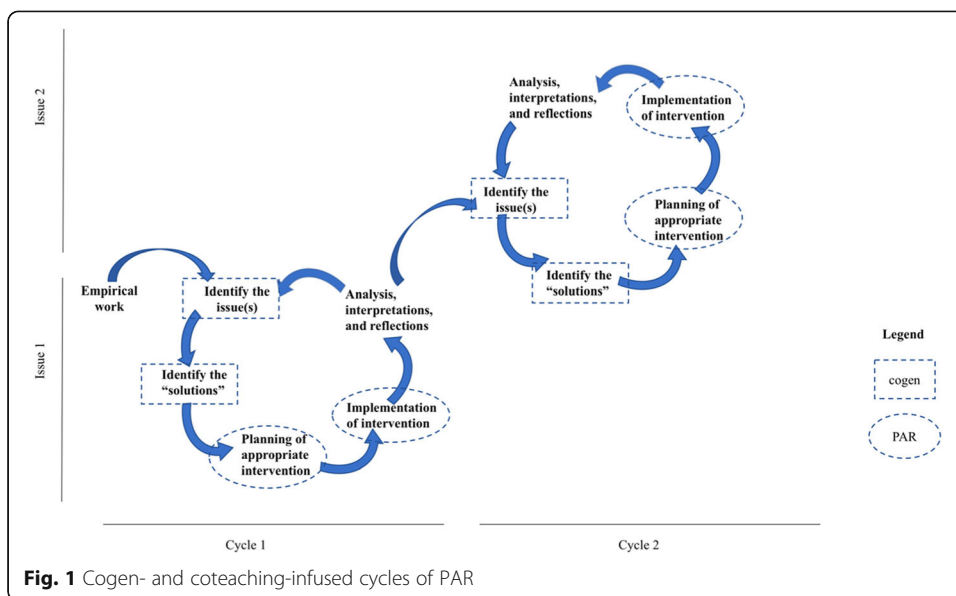


Fig. 1 Cogen- and coteaching-infused cycles of PAR

was roped in as a co-researcher on a large-scale project, of which this paper was based, that was examining the science learning experiences of Singaporean lower track students.

The interest in capturing Faizal’s experience was due to the multiple roles he played in the study. Within the cogen circle, Faizal played the role of the researcher paying close attention to the feedback given by the student and teacher participants. Having more years of teaching experience, Faizal played the role of a mentor to Kenny (the teacher participant) when the latter was unsure how to go about incorporating the students’ suggestions into the subsequent lessons. Faizal, having former experience teaching lower track students in the science topic of interest, volunteered to co-plan the revised lesson with the teacher. In the classroom, Faizal’s role changed from a researcher to co-teacher, working with the teacher “at the elbow of one another” (Tobin & Roth, 2005, p.316). In this paper, we described the processes that led to this change of roles for Faizal and end the paper with a personal reflection on his roles and experiences.

Through this study, we want to encourage teachers doing action research to consider leveraging on cogen and coteaching as platforms to inform their changing practice. In the context of our study, empirical data consisting of lesson observations and lesson videos in the 18 months prior to the intervention study was the basis for initiating PAR. Every PAR cycle entails the identification of an issue, relevant solutions to address the issue, planning and implementation of interventions. Insights gained from the final phase—involving analysis, interpretations, and reflections—was used to identify a new issue and restart another PAR cycle. In Fig. 1, cogen is adopted as the platform to identify one or more issues in the science classroom and appropriate strategy to address the issue(s). Coteaching is adopted as an intervention approach to support the teacher in making classroom change. The final phase of a PAR cycle is the analysis, interpretations, and reflection on the former experiences. This closes the loop of one PAR cycle before a new issue is identified in the subsequent PAR cycle.

The case study classroom

The larger study involved 39 middle schools (Grades 7–10, aged 13–16) that were public and co-educational. Two schools, one located in the eastern and western parts of Singapore, were selected for in-depth case studies in four lower track classrooms each. In Singapore, tracking begins at Grade 7 based upon the students' academic performance in the national examinations taken at the end of Grade 6. Depending on the scores, students are tracked into Express, Normal Academic (NA), and Normal Technical (NT) streams. The NA and NT streams are commonly referred to as the lower tracks and constituted approximately 40% of the yearly student cohort at Grades 7–10 (Ministry of Education, 2017). More details about the Singapore education tracking system can be found in Tan, Teo, and Poon (2016).

This paper reports on one Grade 8 NT classroom in one of the case study schools. The school, founded about 30 years ago, was located at the eastern part of Singapore nested in a public residential district for average income families. The school building was considered old as it had not undergone upgrading works like most other schools. Most of the students, including the two boys reported in this study, came from families with average socioeconomic backgrounds and resided near the school.

Participants of cogen

The cogen involved the two researchers (Tang Wee and Faizal), Kenny (the science teacher), and two students (Nicky and Tim), while the coteaching component only involved Faizal and Kenny.

Tang Wee is an assistant professor and the principal investigator of the research grant that funded this project. Prior to her doctoral studies, she was a former chemistry teacher in a middle school and two high schools. She had prior teaching experience in lower track science classrooms. In this paper, Tang Wee's role is to provide her interpretations and discussion of the data collected during and after the cogen and coteaching.

The two students who participated in the cogen were from the same Grade 8 NT class with a below average (MOE, 2017) class size of 32 students. Tang Wee selected the two boys because they had given assent and obtained parental consent to participate in the study. Nicky was selected, because from the lesson observations, he stood out as the most active student in Kenny's class and Kenny had difficulty getting Nicky's attention in class. Nicky's closest "ally", Tim, often took Nicky's lead. Tang Wee was curious to find out why Nicky was distracted in class, and how he viewed the science lessons and Kenny.

The two main characters of interest in this paper were Faizal and Kenny. Faizal was a former science teacher and level head of the science department in a middle school. At the time of the study, he was a teaching fellow at a Singapore teacher training institute. He was also a collaborator on this research study and a part-time doctoral student of Tang Wee. He participated in this small-scale intervention study mainly for two reasons: (1) to learn what is and how to carry out cogen to inform his doctoral research study design, and (2) to inform his knowledge about science teaching and learning from a critical lens. He enacted the researcher role in the cogen, and subsequently, co-planned and co-taught with Kenny, the first lesson on the topic *Human Reproduction Systems*, which had been revised according to the suggestions made by the two

students. As such, in his role as a mentor to Kenny, co-teacher, and co-researcher, he experienced PAR that would inform his knowledge about science teaching, learning, and research.

Kenny has a bachelor's degree in science and teacher certification. At the time of the study, he had taught for about 5 years at the school. This was his first school and he had taught students across Grades 8 to 10 and from various academic tracks. Kenny participated in the study for 2 years. In the first 18 months of study, the researchers noticed that Kenny had adopted mostly teacher-centered approaches. Similar to other teachers, he had feared that group work would result in too many discipline issues. In one of the conversations with Kenny, he revealed that he had never once asked his students for feedback about his teaching and lessons, or attempted to find out their needs. He had enacted his lessons based on what he thought was good and valuable for students to learn in science. This prompted us to gather feedback on how his students felt about Kenny's science lessons.

The five phases of the study

The research study may be divided into five phases as depicted in Fig. 1. The details of the individual phases are described below.

Phase 1: Observation of lesson trends

Prior to the intervention, we had followed Kenny in two of his lower track science classrooms for 18 months. After the first year of study in one classroom, we continued to observe him teach in another lower track science classrooms in the subsequent year to observe any differences in his teaching. This formed the baseline study to understand what was happening in Kenny's science classroom. After observing minimal change in his teaching approach and increased difficulty handling a few students in his class, we suggested adopting PAR as a framework to support his classroom change.

Phase 2: Introduction and implementation of cogen

While PAR provided the framework for improving teaching practice, cogen offered a concrete platform for the researchers to work *with* the teacher and students to make collective decisions for effecting classroom change that will simultaneously impact more stakeholders. Kenny, Tang Wee, and Faizal attended a two-hour workshop by a research consultant who was well-versed in doing cogen research and actively published in this area. The researcher shared the cogen plan with Kenny and suggested the names of two students, Nicky and Tim, to participate in the cogen. During the cogen, the plan was to have Tim and Nicky watch a video clip of a previous lesson and invite them to talk about their experiences in that lesson.

During the cogen session, Tang Wee explained to Tim and Nicky that the purpose of the cogen was to hear from them their views of the science lessons (authenticity) and all of us involved would learn something from one another. Hence, they were encouraged to be constructive about the suggestions, be willing to share, and respectful so that no one was emotionally hurt. Changes, based upon their plausible suggestions, would be made to the science lessons (tacticity). Kenny also encouraged Tim and Nicky to speak up their minds.

Tim and Nicky watched a video clip of the lesson when Kenny was teaching about the parts of the human body and had students write down keywords describing the function of each body part. The video captured Tim and Nicky as they were sitting at the back of the classroom where the video camera was facing their backs. The students shared their views about the lesson being too teacher-centered and offered several suggestions on ways to make the lesson more interesting. However, not all suggestions were viable. The researchers and teacher explained why some of these suggestions could not be implemented without causing more problems and issues and finally, narrowed down to one suggestion that would be implemented in the next lesson. The suggestion was to make the lesson more student-centered.

Phase 3: Co-planning of subsequent lesson

After the students' left the cogen group, Kenny and the researchers deliberated on the details of the changes to be made in the next lesson. After some brainstorming, Kenny expressed challenges in preparing the new teaching materials in time for the next lesson, which was in 2 days' time, and was not confident if he knew what to do. Having taught the topic previously, Faizal stepped up in his role and offered to work alongside Kenny in preparing the materials for the class activity and to co-teach with him.

Phase 4: Co-teaching of the revised lesson plan

The coteaching of the revised lesson plan involved Kenny and Faizal. Kenny adopted the role of the primary teacher and focused on the delivery of content knowledge as well as the organization of hands-on activity task. Faizal adopted the role of the secondary teacher, attending to students' learning needs during the lesson. Both Kenny and Faizal facilitated the hands-on activity task. The subsequent lessons on the topic were taught by Kenny.

Phase 5: Analysis, interpretations, and reflections

After the implementation of the revised lessons on the topic, the teacher was interviewed to find out his experiences with cogen and coteaching, and how he felt about the revised lessons. Faizal also reflected on his experience doing cogen and coteaching for the first time with another teacher.

In our study, two cycles of PAR were conducted to address two different but related issues. In the first cycle, the identified issue focused on Kenny's teacher-centered approach in his science classrooms. Interestingly Nicky and Tim identified a problem—which coincidentally aligned with the researchers' observations—with Kenny's teaching approach and wanted more activities where students could interact. However, in the revised lesson, Nicky and Tim were observed to be distracted and did not actively and responsibly participate in completing the group activity as instructed; they were engaged in their own play. These episodes were captured on video and used to initiate the next PAR cycle. In cycle 2, Tim, Nicky, and two other students (both girls) were invited to the cogen. However, Nicky backed out at the last minute. The two girls were identified by Tang Wee as they were on task, in contrast to the two boys. This time, the common issue identified by the students was with Nicky and how he had misbehaved in all the classes and not only in Kenny's class. His actions had affected

other students including Nicky. The students also came up with suggestions to help Nicky change. As the implemented change did not involve coteaching, we will focus only on the first cycle of PAR in our discussion.

Gathering and analyzing the data

The data analyzed and discussed in this paper were drawn from one lesson video taken before the cogen, during the cogen, and during the co-taught lesson. Additionally, Kenny was interviewed at the end of the two PAR cycles and Faizal was asked to read the transcribed teacher interviews and write his reflections after that. Table 1 shows the details of the analyzed data.

The data analysis was done by Tang Wee. She approached the analysis using the event-oriented inquiry method (Tobin, 2014). In the analysis, an event is one that shows the trends, patterns, unique phenomena, or contrast to illuminate the changes that occurred. First, the researcher watched every lesson video collected in the 18 months before the cogen. The goal was to select a video clip that illustrated a typical lesson taught by Kenny. By “typical”, we mean that he was consistently adopting teacher-centered approaches such as direct instruction in his lessons. The lesson video clip was transcribed and we used emergent coding methods to distill the characteristics of teacher-centered teaching such as direct instruction and close-ended questions. To provide the audience with a vicarious experience of Kenny’s lessons, we describe the events in the form of vignette (Vignette 1) woven from the coded data and juxtaposed with quotes from the transcriptions to offer a sense of authenticity.

Similarly, the researcher watched the video of the cogen session several times and this time, she focused on the parts where students identified issues and proposed suggestions to improve future science lessons. Again, using emergent coding methods, she coded for the issues and suggestions identified by the students. In the analysis, she focused on the spoken content of the cogen rather than the non-verbal content (e.g., body language, facial expression). Hence, it would be more appropriate to present the data in its original transcribed form (Vignette 2). To preserve the authenticity of the

Table 1 Details on the data analyzed and discussed in this paper

Type of Data	Length of video/audio data	Description of the data
Lesson video taken before cogen (no intervention)	45 min	The lesson was representative of the majority (if not all) of Kenny’s lessons in the lower track classroom lessons in the 18 months prior to the intervention. There was no group work and mostly teacher-centered approaches and some questioning.
Cogen session	25 min	This was the first of the two cogen sessions. Kenny, two researchers, and two students sat around a large table and dialogued about students’ experiences, issues, and concerns in Kenny’s science lessons.
Video of revised lesson informed by cogen	45 min	This lesson took place immediately after the cogen. It was the first lesson on <i>Human Reproductive Systems</i> and the first time students experienced group work.
Teacher interview (after intervention)	40 min	We interviewed the teacher about 1 month after the cogen to find out his views and experience with cogen and coteaching.
Researcher (Faizal) written reflections	–	Faizal reflected on the teacher interviews and his own experience doing cogen and coteaching with Kenny.

dialogue, we selectively transcribed the video and presented the excerpt of the transcription below.

In the event-oriented inquiry of the revised lesson, the researcher watched the lesson video to select the parts of the lesson that highlighted two significant and planned changes—coteaching and group work. The video clip was coded using the emergent coding method and this time, she focused on the elements of coteaching and group work that contrasted with the Vignette 1. For example, she coded for the multiplicity and transitioning of teacher roles in coteaching and factors for successful group work. Then, she wove the episodes into Vignette 2 to describe what happened during the lesson and contrasted it with the typical lesson prior to intervention.

Instead of presenting the teacher interviews separately, Faizal read the transcribed teacher interview and reflected on his and the teacher's experiences. This reflective section, was written from the perspective of a "researcher - teacher practitioner - teacher educator lens". However, to provide a better integrated overview of a researcher's and teacher's cogen and coteaching experience, Faizal was asked to write his reflections after reading Kenny's transcribed interviews and compared it to his own. Tang Wee coded his reflections by focusing on Faizal's and Kenny's changed experiences. Specifically, personal and epistemic changes.

Vignettes and reflections

This section comprises of vignettes and reflections presented in chronological order following the PAR cycle (Fig. 1). Below each vignette is a short interpretive commentary. A longer discussion is provided at the end of this section.

Vignette 1: A typical science lesson before cogen

After spending about 7 min to settle down the students and remind them about the upcoming science test, Kenny began the lesson on the human digestive system. He underscored the importance of the topic in saying,

You need to know how food is digested in your body. Don't you think it's very amazing that the human digestive system—you eat a plate of *nasi lemak* [Malay coconut rice], you eat a plate of chicken rice, you eat a big piece of bread, a big loaf of bread—how does it actually come out and be digested in your body and you get your energy and your nutrients. So, as a human being, you must know your body parts!

Following this, Kenny told students that they must be able to label the key parts of a body. He toggled the Word document on his laptop and went through each part of the body including the mouth, oesophagus, stomach, small intestine, big intestine, rectum, and anus. He explained the function of each body part and the processes that happened. As he explained, he typed in the missing keywords in red and students copied the words in their worksheets. Some students also asked questions such as "What is colon? Where is it?" and added their own knowledge such as "the mouth helps to soften the food". Kenny would respond to the students' questions and acknowledged their comments.

Although the worksheet was completely filled by the end of the lesson, it did not happen without interruptions. There was constant background noise because students

chatted softly among themselves, spontaneously adding unbidden responses as Kenny talked. As such, Kenny's could be heard saying "Listen", "Shh!!" very frequently to get the students' attention. Below is an excerpt to show this:

"Okay, let's move on to the last part. Listen, listen. I know it's a lot of information. You have to try to slowly absorb them. Listen. Shh! Okay, listen. Shh! Now. Let's test. Let's see if you guys are listening to me. Where does the digestion start?"

Kenny walked around the class to check on students' worksheet to make sure the keywords were spelt correctly. He acknowledged their work by putting a stamp on their worksheet. He reminded them about the science test before the end of the lesson.

Interpretive commentary

The purpose of this vignette is to illuminate the teacher-centered approaches and teacher control in Kenny's lessons. Here, we see how Kenny tried to bring in a real-life example and connect it to the topic. However, instead of using artifacts or interactive tools to excite students, he told students that it would be interesting for them to learn about the topic and that they "must" know the different parts of their digestive system because they are human beings. Subsequently, he went through the different functions of each body part in a factual manner and students had to copy the information in their worksheets with blank spaces to fill in. He also spent a lot of effort in classroom management. He explained that the lower track students were rowdy and hence, he had never planned for student group work for fear of loss of classroom control. Nonetheless, he was open to having students ask questions as these did not require students to move out of their seats.

Vignette 2: Cogen transcription excerpt

Below, we show an excerpt of the first cogen and issues raised by Tim and Nicky after watching a video clip of the lesson described in vignette 1. Both students were captured in the video. The purpose of showing them the video was to scope the cogen so that the issues raised concerned them rather than other students.

Researcher: What do you notice in the video?

Nicky: Some of them [students] were not paying attention.

Researcher: Tim, what did you see?

Tim: People lying on the table.

Kenny: How about yourselves in the video?

Nicky: Like very tired like dat [colloquial term].

Researcher: Were you very tired on that day?

Nicky: Ya.

Researcher: Why were you tired on that day?

Nicky: Very boring.

[...]

Researcher: How about you, Tim?

Tim: Talking lor.

[...]

Kenny: Nicky, you said the lesson was boring right. So, why do you think the lesson was boring to you?

Nicky: Talking lah. Like never do anything. Just keep talking.

[...]

Kenny: There was a worksheet that you have to fill in. Does that mean that the worksheet actually doesn't help?

Tim: Because we like to do more experiments. Hands-on.

Researcher: How many times do you go to the laboratory?

Nicky: Less. [...] Less than 20 times.

Kenny: That's quite a lot.

Researcher: Yeah, that's quite a lot. But you want to do more?

Nicky and Tim: [Nod their heads]

Kenny: What other things do you wish we can include in our science experiments?

Nicky: Watch video.

Kenny: Watch video ah? Okay.

Researcher: What kind of videos?

Nicky: Science.

Tim: Yeah.

Researcher: About science? Okay.

Kenny: Then are there other things or lessons that you find very interesting in other subjects which you think I can do the same thing?

Nicky: No. [Shakes his head]

Interpretive commentary

The excerpt in vignette 2 showed Kenny actively involved in the cogen with students as he probed for them to say more about his lessons and encouraged the boys to elaborate on their views. He also directed the two boys to focus on themselves in the video and not only on others. When the students could not say more, he asked them to think about other subject lessons. He showed that he was receptive to their comments by acknowledging their responses. However, the two boys did not provide elaborated responses, possibly because it was their first experience being invited to share their views about the lessons.

Tim's and Nicky's suggestions to revise the lessons included having videos, experiments, activities that allowed movement in class, and group work rather than individual work. But there were suggestions that did not work (e.g., having fewer English lessons) and the teachers and researchers provided in-time reasons to help the students understand this. Following the cogen, Kenny and the researchers discussed about possible changes that could be made to the next lesson which was due to take place in 2 days' time. Given that Kenny was starting the first lesson on the *Human Reproductive Systems* and had limited time to prepare the lesson, he and the researchers decided that they could have students do group work to label the parts of the male and female reproductive systems. The students would be given big pictures of the body parts and slips of papers with printed words for labeling. Students would then put up their work on the whiteboard for peer checking. As such, they would have the opportunity to discuss and work together with their friends to learn about the parts of the male and female reproductive systems instead of copying the words on a worksheet as the teacher enacted direct teaching.

Vignette 3: The revised science lesson after cogen

Kenny began the lesson by explaining to students the importance of maintaining respect when discussing this topic with peers of opposite gender. He grouped the students and had them rearrange their seating so that they could face one another in their groups. However, the class was noisy possibly because it was their first experience at doing group work in this class. Faizal stepped in spontaneously and requested students to give him attention. They complied and listened to him.

Faizal explained why the lesson had changed from direct teaching to group work and his role in the lesson. He laid down three expectations of students—the “three Ps”—participation, proactiveness, and peer respect. He rationalized with students why he had each of these expectations.

After Faizal had laid down the ground rules, Kenny took over the lesson and gave out the materials including A3-size pictures and word labels for them to label the parts of the body. During the group work, Kenny and the researcher walked around to check on the students' work. He noted that one group had all the wrong answers except for one part. He encouraged them to check their answers again. The students spent about 10 min to complete their task. Thereafter, students were nominated or volunteered to label the same diagram on the whiteboard, based upon the group agreed answers. Kenny acknowledged that all the parts were correctly labeled and he would go through the functions of each part in the next lesson. He summed up the lesson by highlighting the four parts that they needed to know in the male and female reproductive system. He told students that they would continue to “play” again in the next lesson by matching the body parts and descriptions of the functions.

Interpretive commentary

This revised lesson was different from Kenny's previous lessons in several aspects. First, the students were asked to do group work. As it was their first experience doing group work, Kenny had to lay down the ground rules and spent time organizing the students into groups. Second, instead of keeping to the front of the classroom, he had to walk around the classroom to facilitate students' group work. Third, Kenny had to resist giving students the answers. Instead, they had to rely on their peers and books for the answers. Fourth, he used the word “play” to describe the group activity hence, suggesting that he wanted his lesson to be fun for students. These qualities were not found in his previous lessons.

Faizal's reflections on PAR, cogen, and Coteaching

This section of the discussion encapsulated Faizal's reflections (written in first person) on his and Kenny's experience engaging in PAR that incorporated cogen and coteaching. The reflective discussion is structured into three sections according to the roles he perceived himself enacting during coteaching. As mentioned earlier, Kenny's interview was woven into Faizal's reflections instead of presenting them separately. In doing so, we can see how Faizal's interpreted Kenny's experience and compared it to his own experience. For each sub-section below, a comparison will be made to his prior experiences in school and how the PAR, cogen, and coteaching process has shaped his understanding of the role of a mentor, teacher and researcher.

Reflection 1: An emergent mentoring role

The need to change the way the science lessons were being taught in the classroom came out strongly during the cogen with Kenny, Tim and Nicky. From the transcribed dialogue, it was evident that the lesson was “boring” for Nicky. He pointed out that the lesson mostly comprised of the teacher talking and the students were in a state of “never do anything”. The feedback given by Nicky resonated with my experience sitting in Kenny’s lessons and observing him teach the class prior to the cogen. His lessons were mostly teacher-centered and student engagement was limited to filling in worksheets most of the time. It did not help that the classroom video projector was faulty and students did not have visuals (e.g., Powerpoint slides and videos) to refer to. Interestingly, Kenny was not aware of students’ feelings of boredom. This was, in part, because he did not talk with students to gather feedback on his lessons. Kenny acknowledged this in saying,

Honestly speaking, this [cogen] is a very deliberate meet-up session with them. If without this cogen, I don’t think I will have the time, or make time specially for them to actually get to know them, like how they feel about science lessons. Because my priority will be given to graduating classes, for sure. So, I think it is a good chance for me to know what they feel about it, and what they hope to see improvement. Then it also made me realized that, “Eh actually I haven’t done group work with them.” As in I did, but I have my hesitations. You know, because of the orderliness. [...] Ya. So, it is a good attempt, to actually get to know them better.

Although Kenny felt that Tim and Nicky were being very “blunt” in telling him in his face that his science lessons were “boring” and caused him to feel embarrassed, he felt, “I’m also happy that I got to hear what they really wanted. I got to try it out. Then at least they feel that their voices are heard. That what I feel.”

The challenge for Kenny was to develop an engaging hands-on activity for his next lesson on the topic of sexual reproduction in human. Even though Kenny had 5 years of teaching experience in school, he had difficulty thinking of alternative ways to deliver the lesson in a teacher-centered manner. Planning a student-centered lesson for lower track students seems to be outside of his comfort zone. The switch in my role from a researcher to a mentor happened when I volunteered to support Kenny by co-planning the lesson with him. This transitioning of role was an unintentional manifestation of the cogen. The intent of co-planning the lesson with Kenny was to share some hands-on activities which I had done with my students in my former school. As a teacher, I had taught Normal Technical students from Grades 8 to 10 and I was well-versed with the syllabus. Through the sharing and co-planning of the lesson, I shared instructional strategies such as jigsaw and picturing labeling (Naylor, Keogh, & Goldworthy, 2004) to shift the lessons from teacher-centered to student-centered. The other changes that we made included crafting short open-ended questions to draw students’ attention back to the lesson. Further, using questioning technique strategy to gain students’ attention helped to replace Kenny’s habit of saying “Listen. Shh!” whenever he needed their attention.

Reflection 2: My coteaching role

I was excited to be given the opportunity to co-teach the revised lesson plan with Kenny. There was some level of uncertainty on whether the lesson would turn out well.

I acknowledged that even though the hands-on activities had proven to engage my students, it may not produce a similar outcome with Kenny's students. In addition, following through the co-planned lesson with coteaching was something different from my past teaching experience when I usually taught a lesson independently. Having the privilege to co-teach the revised lesson with Kenny enabled me to experience first-hand responses of the students towards a lesson that had been revised based upon students' suggestions. The in-class responses from the students could suggest the success of the lesson.

During the classroom teaching, Kenny was the main teacher delivering the content knowledge to students. He began by introducing the topic followed by instructions on how the hands-on activities should be conducted. I played the role of the supporting teacher in the class, facilitating students' learning whenever the need arises. My role as the supporting teacher allowed me to interact more with the students and ensure minimal student disruption during the lesson. Kenny found it useful to have a co-teacher in the classroom. He recalled,

Coteaching, basically, the other teacher can be the assistant in the class. And also immediately close up any gap, let's say, any teaching gap. Definitely another person monitoring the class, attending to the need of the students are attended faster. [...]Imagine there are so many groups that were asking questions. He [Faizal] was at one group and I was at the other group. So, it was a good division of labor.

Despite my presence as the supporting teacher, the noise level from the students increased up to a point when Kenny struggled in giving instructions on the hands-on activity. My decision to step in and establish some form of ground rules using the "3Ps" was to provide support for Kenny so that the hands-on activity could be carried out properly. The "3Ps" set the behavioral expectations for the students in order for them to reap maximum benefit from the revised lesson. When I made the decision to step in and established the "3Ps", I was consciously reminding myself not to overpower Kenny's role as the main teacher. My stepping in was just sufficient to bring order back to the class and allowed Kenny to continue giving instructions to his students.

The lesson managed to be carried out as per planned and the students were participative in matching the parts of the human reproductive system with the correct label. The lesson was engaging and there was more interaction between Kenny and his students when he started calling them up to the whiteboard to label the parts of the reproductive system.

Reflection 3: My co-researcher role

Cogen was first introduced to me in the early stage of my doctoral program. Cogen captured my attention since it was a term that I was unfamiliar with as a non-academic. I was intrigued to find out the difference between cogen and other forms of dialogue such as classroom discourse, classroom talk and teacher-student dialogue and how the different types of dialogue helped to catalyze change in the classroom. The quest in searching for the answer led me to define two domains in my literature review search and they were dialogue and classroom change. Albeit I somewhat had an idea of what cogen was about after reading the literature and attending a half a day workshop

by the research consultant, my firsthand involvement in the process of implementing cogen with the participants of this study made me realize the potential of using cogen to catalyze change in the teaching and learning praxis within the local context.

One of the key elements of cogen which I felt was critical in invoking change was the equal power relationship between the teacher and students. Allowing the students to have a voice provided Kenny with an honest feedback on his lessons and changes that students would like to see. This evoked change in the way Kenny delivered his revised lesson. Similarly, having equal power relationships between Kenny and me had allowed us to plan a lesson together and share teaching experiences as we enacted our separate roles. As a result, changes in the instructional strategy and student engagement were possible.

Overall interpretive commentary

This cogen- and coteaching-infused PAR may be described as stimulus for change for Faizal and Kenny. Their changed experiences embodied epistemic and personal qualities. By epistemic, we mean that the experience entailed the production of new knowledge that was emergent or constructed through the process of participating in the knowledge generating process. This knowledge included the knowledge about self and others and it was not available to Faizal and Kenny prior to participating in the cogen- and coteaching-infused PAR. For example, it did not occur to Kenny that he should find out from his students how they felt about his lessons. Even if he did, he did not develop the critical consciousness to solicit feedback, in part, due to his focus on another group of students whom he thought needed his attention more. Also, he did not seem to know how to go about soliciting students' feedback on his lessons other than simply asking them. Kenny and Faizal did not know about the power of cogen and coteaching as a pedagogy that could bring about change in the classroom. In participating in this study, they acquired new pedagogical knowledge that aided change in teaching practice, knowledge about how students can learn better, and knowledge about engaging cogen as a teacher professional development and participatory research methodology.

The experiences that were personal were those that resulted in changes in the self. For example, through the coteaching process Faizal became aware of the power relationships (Tobin & Roth, 2005) in sharing the teacher authority in the classroom. This authority was not equally shared between Kenny and him as he was cognizant that the students were Kenny's students and not his, and that he was simply "stepping in" to provide temporary support and not a real mentor assigned to "coach" Kenny. When writing his reflections, Faizal unpacked the three different roles that he played, illuminating his awareness of multiple subjectivities (Davies, 2013) which may affect how he interpreted his influence on biasing the outcome of the intervention study.

Informing teaching, research, and practice

The findings of this study have implications to teaching, research, and practice. We first discuss the implications through the lens of PAR experiences of Faizal and Kenny. The implication for future research will be highlighted in the conclusion section.

Implication of cogen on teacher education

Prior to the study, "cogen" was a new term to Faizal and Kenny even though they had at least 5 years of teaching experiences in different schools. The idea of getting students

together with their teacher, to collectively engage in a discussion towards change in teaching and learning praxis was something uncommon and rarely practised in most schools. This is partly due to the conventional view that the teacher is the respected authority figure and has the full autonomy to decide what is best for students.

An important implication of this study is to introduce and equip teachers, through professional development, with the knowledge and practice of cogen. When teachers are well-versed with cogen, they will be able to adopt it more frequently when facing problems in the classroom such as poor student engagement or other related behavioral issues.

Implication of cogen in changing teaching praxis

It took at least two cogen sessions before the student participants opened up and contributed ideas towards catalyzing change. By providing a safe environment for the cogen to occur, where the students could express their views, critique and provide suggestions for improvements without having the fear of being subjected to disciplinary actions by the authority figure of the teacher can improve the teacher-student rapport. There was a higher level of mutual respect and trust between the participants in the cogen circle as they leaned towards collective efforts for change that benefit self and others.

Implications of cogen for closing the research-practice gap

In this study, we illuminated one additional benefit of cogen that was not reported in the previous literature. Cogen, coupled with PAR, had bridged the gap between research and practice. This is illuminated through the experience of Faizal who was a co-researcher and, at the same time, a teacher educator who would soon return to school to teach. He had learned how to carry out cogen, and the support structures and conditions to facilitate change following the cogen. Hence, he was equipped with the research and practical knowledge and skill of using cogen as a professional development tool to enhance science teaching and learning praxis through research.

Implication for future research and conclusion

Although cogen has been shown to produce positive change in the literature, little is known about the effect of cogen on the learning praxis of students. Thus, we call for research communities to examine the possible changes that could occur in students as they participate in cogen with their teachers. Findings from such research could provide educators in Singapore with a more holistic view on the catalytic potential of cogen.

Limitations of the study

In this paper, we reported a small part of a much larger study involving the understanding of lower track students' science learning experience in Singapore classrooms. As mentioned in the introduction, this was our first attempt at using cogen to test out its potential as an "intervention" tool or platform for informing classroom change. We do not claim to have achieved complete success in this attempt as we think that the students were not completely forthcoming in sharing their views. This is understandable as the students were probably not used to being consulted on their views of their

teachers' teaching and most likely found it intimidating to speak up in the presence of several adults (including their teacher), even though they had been encouraged to talk freely. Hence, there was a lot of prompting on the part of the teacher and researchers as they "nudged" the students to elaborate on their views and suggest plausible strategies to address the issues raised. We also realized that to be able to conduct a successful cogen, requires the maturity of all the people involved to think beyond their personal interests and wants, and consider the needs and views of those who are not represented at the cogen session. Nonetheless, our experience at this first attempt has been encouraging and enlightening. It is an enriching experience to actually do cogen rather than just read about it. We conclude from this experience that cogen can potentially be used to inform change in some Singapore classrooms where: (1) teachers are willing to *work with* students, and (2) students are regarded as potential resource for informing change in practice as opposed to being "the problem".

Acknowledgements

This research was supported by a grant (OER51/12TWT) from the Office of Education Research, National Institute of Education, Nanyang Technological University, Singapore. The opinions expressed are those of the authors and do not represent the views of the funding agency. We greatly appreciate the teachers and students in this study.

Funding

The data presented in the manuscript were obtained from a funded research project. The funding agency is National Institute of Education, Office of Education Research (NIE OER), under the project number OER51/12TWT.

Availability of data and materials

The first author is the principal investigator (PI) of the project. Human ethics clearance from the PI's university (Nanyang Technological University) has been obtained at the beginning of the study. All data were used according to the approved ethics guidelines.

Authors' contributions

TWT was the Principle Investigator of the grant that was used to fund this study. She was responsible for the collection and analysis of the data reported in this manuscript. She cowrote about 50 % of this manuscript. MFBB was a collaborator of the grant that was used to fund this study. He participated in the cogen and coteaching sessions reported in this paper. He co-wrote about 50 % of this manuscript. ALT is currently co-supervising Faizal in his doctoral research study together with TWT. As a scholar who has the knowledge and experience doing cogen and action research, she performed the role as a knowledgeable other and provided valuable inputs that helped to shape the revised manuscript. All authors read and approved the final manuscript.

About the authors

Tang Wee Teo is an Assistant Professor at the National Institute of Education, Nanyang Technological University, Singapore. Her research focuses on critical issues in science education, in particular, those that concern students labeled as "low achievers". The study reported in this paper was based on her large-scale funded project about students in lower track classrooms in Singapore. She is currently co-supervising Faizal in his doctoral research study with Aik-Ling.

Mohamed Faizal Bin Badron is a Teaching Fellow at the National Institute of Education, Nanyang Technological University, Singapore. Prior to this position, he was a Head of Department (Science) at a public Singapore school. He was a collaborator of the grant that was used to fund the study reported in this paper. Faizal is currently pursuing his doctoral degree and his project involves the physiological measurements of cogen processes.

Aik Ling Tan is an Associate Professor at the National Institute of Education, Nanyang Technological University, Singapore. Her current research interests deals with students' perspectives and ideas about science as inquiry and how they construct their learning experiences through cogen with their teachers. She is co-supervising Faizal on his PhD research study with Tang Wee.

Competing interest

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 29 March 2017 Accepted: 13 December 2017

Published online: 29 December 2017

References

- Creswell, J. W., Hanson, W. E., Clark Plano, V. L., & Morales, A. (2007). Qualitative research designs: Selection and implementation. *The Counseling Psychologist*, 35(2), 236–264.
- Davies, B. (2013). Beyond dualism and towards multiple subjectivities. In L. K. Christian-Smith (Ed.), *Texts of desires: Essays of fiction, femininity and schooling* (pp. 145–173). Oxon, NY: Routledge.
- Heron, J., & Reason, P. (2001). The practice of co-operative inquiry: Research with rather than on people. In P. Reason & H. Bradbury (Eds.), *Handbook of action research* (pp. 179–188). Thousand Oaks: SAGE.
- Im, S., & Martin, S. N. (2015). Using cogenerative dialogues to improve coteaching for language learner (LL) students in an inclusion science classroom. *Asia-Pacific Journal of Teacher Education*, 43(4), 355–369. doi:10.1080/1359866X.2015.1060295.
- Kemmis, S., & McTaggart, R. (2005). Communicative action and the public sphere. In *The Sage handbook of qualitative research* (3rd ed., pp. 559–603).
- LaVan, S. K. (2004). *Cogenerating fluency in urban science classrooms. Unpublished doctoral dissertation*. Philadelphia: University of Pennsylvania.
- Martin, S. (2006). Where practice and theory intersect in the chemistry classroom: Using cogenerative dialogue to identify the critical point in science education. *Cultural Studies of Science Education*, 1(4), 693–720.
- Ministry of Education (MOE) (2017). Education Statistics Digest 2017. Retrieved on December 16, 2017 from https://www.moe.gov.sg/docs/default-source/document/publications/education-statistics-digest/esd_2017.pdf
- Naylor, S., Keogh, B., & Goldsworthy, A. (2004). *Active assessment: Thinking learning and assessment in science*. NY, NY: Routledge
- Ritchie, S., Mackay, G., & Rigano, D. (2006). Individual and collective leadership in school science departments. *Research in Science Education*, 36(3), 141–161.
- Roth, W. M., & Tobin, K. (2001). The implications of coteaching/cogenerative dialogue for teacher evaluation: Learning from multiple perspectives of everyday practice. *Journal of Personnel Evaluation in Education*, 15(1), 7–29.
- Roth, W. M., & Tobin, K. (2010). Solidarity and conflict: Aligned and misaligned prosody as a transactional resource in intra- and intercultural communication involving power differences. *Cultural Studies of Science Education*, 5(4), 807–847.
- Salleh, H. (2006). Action research in Singapore education: Constraint and sustainability. *Educational Action Research*, 14(4), 513–523.
- Siry, C., & Martin, S. N. (2014). Facilitating reflexivity in preservice science teacher education using video analysis and cogenerative dialogue in field-based methods courses. *Eurasia Journal of Mathematics, Science & Technology Education*, 10(5), 481–508.
- Siry, C. A. (2011). Emphasizing collaborative practices in learning to teach: Coteaching and cogenerative dialogue in a field-based methods course. *Teaching Education*, 22(1), 91–101.
- Stith, I., & Roth, W. M. (2010). Teaching as mediation: The cogenerative dialogue and ethical understandings. *Teaching and Teacher Education*, 26(2), 363–370.
- Tan, K. C. D., Teo, T. W., & Poon, C.-L. (2016). Singapore science education. In M.-H. Chiu (Ed.), *Science education research and practice in Asia: Challenges and opportunities* (pp. 155–174). Singapore: Springer.
- Tobin, K. (2006). Learning to teach through coteaching and cogenerative dialogue. *Teaching Education*, 17, 133–142.
- Tobin, K. (2014). Twenty questions about cogenerative dialogues. In K. Tobin & A. Shady (Eds.), *Transforming urban education* (pp. 181–190). Rotterdam: SensePublishers.
- Tobin, K., & Roth, W. M. (2002). Evaluation of science teaching performance through coteaching and cogenerative dialoguing. In J. Altschuld & D. Kumar (Eds.), *Evaluation in science education in the 21st century* (pp. 187–217). Dordrecht, Netherlands: Kluwer Academic Publishing.
- Tobin, K., & Roth, W. M. (2005). Implementing coteaching and cogenerative dialoguing in urban science education. *School Science and Mathematics*, 105(6), 313–322.
- Tobin, K., & Roth, W. M. (2006). *Teaching to learn: Perspectives from the field*. Rotterdam, The Netherlands: Sense Publishers.
- Wassell, B., & LaVan, S. K. (2009). Tough transitions? Mediating beginning urban teachers' practices through coteaching. *Cultural Studies of Science Education*, 4(2), 409–432.

Submit your manuscript to a SpringerOpen® journal and benefit from:

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► springeropen.com
