

# A Cogenerative Dialogues among Pre-service STEM Teachers on Nurturing a Culturally Responsive Learning Environment for Effective STEM Classrooms and Reflexive Practices on Thai Sociocultural Issues Classroom

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## Abstract

In this study, we investigated five pre-service STEM teachers' cogenerative dialogues during the STEM teaching method course. A cogen was conducted to understand the challenges faced by participants when they are learning how to teach STEM in K-12 schools. During the course, we intend to introduce cogen as a pedagogical tool to pre-service STEM teachers to cultivate a democratic, equitable, and student-centered classroom. We adopted a hermeneutic phenomenological approach to describe and interpret participants' lived experiences as a learner. We audiotaped and transcribed our interviews and cogen with participants. Data analysis through qualitative content analysis. Several themes emerged from the vignettes, including traditional teacher identity in Thailand, students' fear of expressing themselves, and STEM education as an opportunity for cultural change. We can see that certain aspects of the Thai sociocultural context create some challenges for STEM teaching and learning: In the Thai sociocultural context, the role of the teacher is often dominant in the classroom setting. This culture's effect on teaching and learning STEM. From the findings, STEM teachers in Thailand need to shift their teaching style to a student-centered approach. By nurturing a democratic classroom culture and promoting autonomous thinking, adding reflective thinking, and providing students with an opportunity to share their ideas. Fostering a democratic culture in STEM classrooms through regular co-generative dialogues allows students and teachers to get effective STEM classrooms.

**Keywords:** Cogenerative Dialogues; Reflexive Practices; Sociocultural Issues; STEM Naturing Culture

## Introduction

STEM education in Thailand faces several challenges that hinder effective teaching and learning in science, technology, engineering, and mathematics. There are some issues/problems such as many teachers lack adequate training in modern STEM teaching methodologies. We found Thai teachers' professional development opportunities are often limited, leading to a reliance on traditional teaching methods that do not effectively foster inquiry-based learning. Also, the cultural attitudes that in some cases, cultural attitudes towards science and technology can discourage students, particularly girls, from pursuing STEM subjects. Societal perceptions may undervalue careers in these fields, leading to lower interest and participation rates. We found the traditional teacher identity in Thailand, students' fear of expressing themselves, and STEM education as an opportunity for cultural change. We can see that certain aspects of the Thai sociocultural context create some challenges for STEM teaching and learning: In the Thai sociocultural context, the role of the teacher is often dominant in the classroom setting. This culture's effect on teaching and learning STEM. It shows this teaching style is not common in Thailand, which means that many students have never had the opportunity to meet a good STEM teaching role model. However, communication between teachers and students in science classrooms will nurture a culturally responsive learning environment for effective STEM classrooms.

Since August 2020, in several public universities in Thailand, college students have initiated or participated in protests, demanding political reforms. The protests began as a peaceful movement, but later on morphed into violent acts. There is clearly a need among the youth to express their voices and exert their influence in civic affairs. The question here is how educators can empower students to exercise their civic rights in a mindful, safe, and nonviolent manner. These protests reflect a need to educate citizens to listen attentively, to form arguments based on facts and reasoning, to refrain from interrupting or even physically attacking speakers with opposite views, and to become aware of the influence of ideologies, and to detach from negative thoughts and emotions.

Recently, the US' Next Generation Science Standards emphasizes the importance of developing argumentative skills among students in STEM education. In the past decades, STEM education has been promoted as an interdisciplinary learning approach that removes the barriers among disciplines (i.e., science, technology, engineering, math and other subjects), and apply scientific inquiry skills to solve real world problems in authentic contexts. A central feature of the language of scientific inquiry is

engaging in argumentation around competing theories, methodologies and aims. Engagement in scientific argumentation helps students understand the culture in which scientists live, and how to apply science and engineering for the benefit of society” (NGSS Framework, 2018). Moreover, it is vital for personal decision making and participating in civic and cultural affairs. Unfortunately, these skills are rarely practiced in the classrooms. Effective STEM education requires a student-centered learning environment that encourages creativity, teamwork, critical thinking, and communication among students. However, according to the reports from TIMSS (2003) and TALIS (2009), despite many years of educational reforms, many teachers of science across the world are still using traditional teacher-centered approaches. For example, in Thailand, Ketsing & Roadrangka (2010) and Faikhamta et al. (2018), discovered that science teachers in Thailand place too much emphasis on delivering facts, memorization, and assessment-driven learning, rather than developing scientific inquiry skills or knowledge in the nature of science. The teacher-centered approach is based on the belief that teachers hold the authority to truths and students are passive receivers of knowledge delivered by teachers. When most discourse in the classrooms is dominated by teachers, students do not have sufficient practice in scientific dialogues and developing their reasoning skills (Duschl & Osborne, 2002). Such kind of traditional practices in teaching and learning science are undermining the agency of students to become autonomous thinkers.

Recently, reflexive practices such as cogenerative dialogues have been used to promote the quality of communication between teachers and students in science classrooms. Cogenerative dialogues (or cogen) is a multilogical research methodology developed by Kenneth Tobin and his colleagues that aims to address the needs of all members of a community through meaningful dialogues surrounding a salient topic of interest (Tobin, 2012). During a cogen, all members have an equal opportunity to participate in the conversation and no one’s voice is prioritized over others. The goal of cogens is to transform the worldviews and practices of all participants through learning from each other in a nonjudgmental way. Cogens help promote students’ ownership and agency of their learning. We propose that cogen can be a valuable reflexive tool for STEM teachers to understand the teacher | students’ dialectical relationship and nurture a democratic, equitable, and culturally responsive learning space that promotes meaningful discussions.

## Research Objectives

To study cogenerative dialogues among pre-service STEM teachers of communication between teachers and students in science classrooms to nurture a culturally responsive learning environment for effective STEM classrooms and study reflexive practices on Thai Sociocultural Issues in the classroom

## Literature review

Teaching STEM effectively through co-generative dialogue (cogen) between teachers and students can create a more interactive and engaging learning environment. Using co-generative dialogue in STEM education empowers students and enhances their learning experience. By fostering collaboration, encouraging open communication, and integrating hands-on activities, teachers can create a dynamic and effective STEM learning environment that prepares students for future challenges.

Cogenerative dialogue is a group discussion surrounding a topic of interest, such as a recent sociocentric/sociocultural issue. The focus of a cogen is not about looking for agreement or coherence, but rather on the nuances/differences in multiple voices. It aims to include the voice of all stakeholders so that participants can learn from each other (Rahmawati & Koul, 2016) Recently, reflexive practices such as cogenerative dialogues (cogens) have been used to promote the quality of communication between teachers and students in science classrooms. The goal of cogens is to transform the worldviews and practices of all participants through learning from each other in a nonjudgmental way (Tobin, 2006).

Cogenerative dialogues and equity in education are critical components in creating an environment where all students have equal access to learning opportunities. Cogenerative dialogues, which involve students, teachers, and other stakeholders collaborating to improve classroom dynamics and learning outcomes, can play a crucial role in promoting equity in education (Geelan et al., 2006) Equity in education refers to the principle of ensuring that all students have access to the same resources, opportunities, and support, regardless of their

background, identity, or abilities. It involves addressing systemic barriers and creating a level playing field for all students to thrive academically and socially. Cogenerative dialogues, as a collaborative and inclusive approach, can help to address issues of equity in education by fostering a more democratic and inclusive learning environment (Higgins & Moeed, 2017).

In cogenerative dialogues, students and teachers come together to discuss and address challenges that arise in the classroom. These dialogues provide an opportunity for students to voice their concerns, offer suggestions for improvement, and engage in problem-solving alongside their teachers. By involving students in the decision-making process, cogenerative dialogues help to empower them and give them a sense of ownership over their learning environment. This can be especially impactful for marginalized students who may feel disenfranchised or unheard in traditional classroom settings (Tobin et al., 2003).

Furthermore, cogenerative dialogues can help to disrupt power dynamics and hierarchies within the classroom. By creating a space where students and teachers can engage in open and respectful dialogue, cogenerative dialogues can build a more equitable and collaborative learning environment. Students from diverse backgrounds or with different learning needs can feel more included and valued, leading to a stronger sense of belonging and a greater willingness to participate and engage in their learning (Gupta et al., 2014).

In addition to promoting equity within the classroom, cogenerative dialogues can also contribute to broader educational equity by promoting a more inclusive and student-centered approach to teaching and learning. By engaging students in the process of decision-making and problem-solving, teachers can better understand the unique needs and experiences of their students and make more informed and equitable decisions about their educational experiences.

In conclusion, cogenerative dialogues can play a critical role in promoting equity in education by fostering a more collaborative, inclusive, and democratic learning environment. By involving students in the decision-making process and disrupting traditional power

dynamics, cogenerative dialogues can help to address issues of equity and create a more inclusive and empowering educational experience for all students (Tobin & Roth, 2006). As educators, it is essential to recognize the value of cogenerative dialogues as a tool for promoting equity in education and work to incorporate them as a fundamental aspect of classroom practice.

### **STEM Education**

STEM education has been promoted as an interdisciplinary learning approach that removes the barriers among disciplines (i.e., science, technology, engineering, math, and other subjects), and applies scientific inquiry skills to solve real-world problems in authentic contexts. The US' Next Generation Science Standards emphasizes the importance of developing argumentative skills among students in STEM education. Engagement in scientific argumentation helps students understand the culture in which scientists live, and how to apply science and engineering for the benefit of society” (NGSS Framework, 2018). Moreover, it is vital for personal decision-making and participating in civic and cultural affairs. Unfortunately, these skills are rarely practiced in the classroom (Kennedy& Odell, 2023)

STEM education requires a student-centered learning environment that encourages creativity, teamwork, critical thinking, and communication among students. However, according to the reports from TIMSS (2003) and TALIS (2009), despite many years of educational reforms, many teachers of science across the world are still using traditional teacher-centered approach. For example, in Thailand, Ketsing & Roadrangka (2010) and Faikhamta et al. (2018), discovered that science teachers in Thailand place too much emphasis on delivering facts, memorization and assessment-driven learning, rather than developing scientific inquiry skills or knowledge in the nature of science. Teacher-centered approach is based on the belief that teachers hold the authority to truths and students are passive receivers of knowledge delivered by teachers. When most discourse in the classrooms are dominated by teachers, students do not have sufficient practice in scientific dialogues and developing their reasoning skills (Duschl & Osborne, 2002). Such kind of traditional practices in teaching and learning science is undermining the agency of students to become autonomous thinkers.

### A sociocultural perspective to understand STEM education

The key to successfully innovative teaching practices lies in the teachers' beliefs and commitment. Teachers' beliefs in teaching and learning originate from their upbringing, schooling experiences, and the historical and cultural context one is embedded. Teachers' beliefs have a significant impact on teaching practices and curricular implementation because teachers are the main vehicles driving educational reform (Roehrig, Kruse, & Kern, 2007). But quite often, teachers are not aware of the beliefs that form the foundation of their worldviews, unless they are prompted to self-reflect or they are faced with dilemmas.

## Research Conceptual Framework

This study adopts a sociocultural perspective conceptual framework to understand preservice teachers' perspectives of STEM education through interpreting their narratives about their prior learning experiences in schools. We seek to explore the contextual factors that shape the worldviews and being of the participants, and the associated opportunities and challenges for STEM teaching and learning in Thai culture through cogenerative dialogues way to understand STEM education.

## Methodology

We invited five Thai preservice teachers, who are graduate students of a Thai university, to participate in a sixteen-week STEM method course instructed by the first author. Individual semi-structured interviews were conducted to get to know the backgrounds and perceptions of STEM of each participant before the course. In the middle of the course, a cogen was conducted to understand the challenges faced by participants when they are learning how to teach STEM in K–12 schools. We are aware that there are multiple perspectives of STEM education and we embrace diversity as a valuable learning resource that promotes creativity and innovation. We intend to introduce cogen as a pedagogical tool to preservice STEM teachers for cultivating a democratic, equitable, and student-centered classroom. We adopted a hermeneutic phenomenological approach to describe and interpret participants' lived experiences as a learner and later a teacher of science. Hermeneutic phenomenology is an event-oriented, personal, and contextualized form of inquiry that aims to illuminate social reality through understanding the subjective life worlds of individuals (Patton 2017). We audiotaped and transcribed our

interviews and cogen with participants. Several themes emerged from the vignettes, including traditional teacher identity in Thailand, students' fear of expressing themselves, and STEM education as an opportunity for cultural change.

## Results

### Part 1. The cogen narrative dialogue transcript between teacher and participants about science teaching and learning experience.

**Question 1:** Could you tell me how was your experience in learning science? The answer from students:

Student A:	I study in small school. My science teacher always teaches me by giving a lecture. They teach me about the content on the whiteboard. They always speak and talk for whole class.
Student B:	I learnt science by lecture all the time. Sometimes teachers let student did science laboratory but following the cookbook.
Student C:	I study science in classroom all the time. My science teacher teaches me by lecture and ask me some questions. They use a PowerPoint for teach us. They had homework for us and sometimes we did an easy experiment in the class together.
Student D:	My science teachers teach me by lecture. I follow the book and do some science activity in the classroom with teacher sometime. They explain us the content on the whiteboard and give me a homework.
Student E:	I learnt science by lecture. Almost my science teachers teach me by using Power Point. Sometimes they teach on the whiteboard. We have a laboratory but I following the step that teacher told us and following the instruction from the book.

**Question 2:** How do you think about your traditional experience in science teaching? Is it good or not, and why? The answer from students:

Student A:	Umm.. I think it's not good because I learn only content but never have chance to practice or do some experiment by myself. I think if I have chance to try to do some experiments too, it will be good.
Student B:	No, I think it's not good. Sometimes it so boring that teacher always talk and talk. Sometimes I did not understand what the teacher said but I afraid to ask them.
Teacher:	<b>Why were you afraid to ask teacher?</b>

Student B:	Umm. because I was afraid to disturb the teacher and make other students think I'm stupid, no one ask questions in the classroom. So, I don't want to ask in front of other people.
Student C:	Me too. I felt shy to ask teacher because I feared that teacher would ask me back why I did not understand. My friends also keep quite even they didn't understand but no one want to ask in the classroom.
<b>Teacher:</b>	<b>So, how did you solve this problem when you didn't understand on what teacher teach?</b>
Student C:	For me, sometimes I just asked my friend who was the smartest in the class but sometimes I read the book by myself and looked for the answer when I went back home.
<b>Teacher:</b>	<b>And how about you? Are you afraid to ask teacher too?</b>
Student D:	Yes... I never ask teacher too when I did not understand the science content in the classroom too and I think it was not good that teachers only talk and teach through PowerPoint only
Student E:	because it so boring. Some of my friends, felt asleep in the classroom too. For me, I think it good that we can learn the full content from teacher but sometime it is only content so the teacher should make the science class to be fun and have more exciting for get interested from student.
<b>Teacher:</b>	<b>So, do you still ok with this traditional lecture style?</b>
Student E:	I did not have any problem with teaching content only on the whiteboard but I have a problem about the teacher should add more fun science activity that help student thinking and do some practice hand on activity more. The teacher should open the opportunity for students to ask
<b>Teacher:</b>	more.
Student E:	<b>So, do you have any problem to ask questions with your teacher too?</b> Ummm...yes sometimes I am not brave enough to raise my hand and ask my teacher in the classroom because all of friends are so silent and teacher never provide us a chance to talk much in the classroom. So, I just listen on what teacher said and follow it. I don't want teacher think why I am the only one who ask question. I did not want them feel bad, if I ask, the teacher may think they did not teach well or why I did not listen to them when they teach us. Something like that.

**Part 2: The cogenerative dialogue transcript between teacher and participants about science STEM teaching experience,**

**Question 3:** Do you know the STEM teaching before? The answer from students:

Student A:	No, I never have any experiment about STEM teaching before when I study in primary school till high school. I just know and learn some session about STEM class when I study in university.
Student B:	Yes, same there. My science teacher in the school never taught STEM. I learned only pure science like Physics, Chemistry or Biology but never try or learnt something about STEM from my science teacher.
Student C:	Me too...I did not have any experience about STEM teaching when I studied at school.
Student D:	I also did not have any experience about STEM too. Just one class when I studied in the university.  I did not have chance to study about STEM before and my science teacher when I study in primary and secondary also never teach me about STEM. So, I did not see much about STEM
Student E:	teaching. I know and I learnt only about general science teaching such as teaching biology.
<b>Teacher</b>	<b>Do you think your prior experience before affect your STEM teaching?</b>
Student A:	Yes...I think it does. Because I know the basic information about the STEM that we have to do some activities, but I don't have any ideas how to design the activity.
Student B:	Yes, same. I know only how to do simple experiment and conduct a lab exercise, but I don't know how to do STEM experiments.
Student C:	I don't know how to use four disciplines into the activities, but I know STEM we need to use Science, Mathematics, Engineering and technology.
Student D:	Me too...I think it effect because I never have chance to think about crating ideas about activity. I never have chance to discuss or share ideas with friend much in the classroom. So, I think it hard for me if I have to teach STEM by myself because I never practice to think or create any activity by myself before.
Student E:	Me too. It quite effect on me. I cannot use any experience about science teaching in the past to teach STEM because I never have chance to practice or did some hand-on activity by myself. I learn only science content from my teacher, but I did not know about other discipline for integrated in the STEM classroom.

<b>Teacher</b>	<b>Do you have any ideas on improving STEM teaching?</b>
Student A:	I think, the teacher should provide the students to have chance to express their ideas by themselves.
Student B:	Yes, I agree with that, I love to do experiments, I think if teacher provide us to do many experiments in the science class, it would help us to understand science and STEM concept more. Let us design the activity and do experiments by ourselves often.
Student C:	For me, I think teacher should show or demonstrate us how to do STEM activity and how to create the activity for make students learn and fun with it.
Student D:	Yes, teacher should let us do some activities like a hand–on activity practice in the classroom by ourselves not only follow the handbook. The teacher also should let student explore and share ideas in the activity more. I also love when I learn by doing not only listening. It helps me learn better and have a good memory.
Student E:	For me, the teacher should ask students to thinking and sharing ideas more because STEM teaching need the co–operation between teacher and students. We should have chance to do more hand–on activities. More experiments. Less lecture but focus on the how to practice design STEM activity by ourselves.
Student A:	Yes. The teacher should give me and show me more example of STEM activity and let student design and create STEM activity by themselves too. The teacher should has a role to be guiding not lecturer and students should have chance to do a group work and discuss among themselves and share ideas with teacher too.

**Part 3. The cogenerative dialogue transcript between teacher and participants about effect on teaching STEM**

**Question 4:** How do you think about the strategies for STEM teaching? Between problem base learning, inquiry base learning, modelling base learning and SSI base learning? The answer from students:

Student A:	For me, I like the modelling base learning Teacher: Why? Because I think it’s easy to understand. I can see the whole picture on what students thinking through their model.
Student B:	Yes, me too. I like modelling base for teaching STEM as well because I think it easily for students to understand through the model. Like they can see the picture from their ideas through model

	<p>that their build it up by themselves. It's a fun and make student feel excited to build up something. They have an action.</p>
<p>Student C:</p>	<p>Yes, I agree with that. Model also make student clearly understand because they can see the picture clearly. Model can explain on something that we cannot see or hard to understand but model make it simplify for students and teacher. <b>Teacher: How?</b> Like teacher no need to use difficult question to ask students, we can use simple questions as Do you think how our lung function work? Like a simple question but student can have chance to explore and build up lung model by themselves. Not only the students can learn knowledge but also, they have fun time to make a model and teacher can check their understanding through the model easily because model is representative of their thinking already.</p>
<p>Student D:</p>	<p>For me, I like the inquiry base learning because I think the question make a students interested to learn and if the teacher has a wonderful question, its lead the student has a motivation to seeking the answer.</p>
<p>Student E:</p>	<p>But for me, I chose the problem base learning because I think asking the question is quite hard for me. I don't know how to ask the question but I think, setting the problem is look easily for me. Then students can solve the problem by themselves. I also can select the problem or situation that the students face in their daily life. So, easy for me and easy for students to understand.</p>
<p><b>Teacher</b></p>	<p><b>Why nobody chose the SSI?</b></p>
<p>Everyone:</p>	<p>No, I think it's hard, hard to find the situation like that and hard to related with STEM. The topic would be really too specific.</p>

**Part 4: The cogenerative dialogue transcript between teacher and participants about discussion and reflective activity after class.**

**Question 5:** Do you like to share ideas and have a discussion like this? The answer from students:

<p>Student A:</p>	<p>Yes, I like it. It makes me feel motivate and have chance to say and express my feeling on what I want to say. Then teacher can know what the student thinking and what the student wants.</p>
<p>Student B:</p>	<p>Yes, me too. I think it's good because we can see what we did and what we need to improve from other people view.</p>

Student C:	Yes, we can see the opinion from other people and see what they are thinking then we can learn and deal with it. Sometimes we can understand ourselves more from discussion and from argumentation.
Student D:	Yes. Argumentation make us clear and understand more in content. Sometimes I was confused but when I have chance to discuss or have argumentation with friends or teacher, it's really help me understand and clear more.
Student E:	Yes. When we have chance to express feeling, I feel relaxed and feel less stress from studying. When I have open conversations with teacher and my friends, I feel comfortable more and know what the mistake I did or what is the point that I still misunderstanding and I can adapt and improve myself better after discussion.
Student B:	Yes, we can learn and improve ourselves from other opinions. Argumentation make me feel understand better. This part also practices us to have a thinking and criticizing skill too. I like it. I love to share my opinion and love to listen on what other people thinking. For compare and take it for improve myself too.

## Discussion

STEM as a catalyst for cultural change: Thai sociocultural context

We can see that certain aspects of the Thai sociocultural context create some challenges for STEM teaching and learning: In Thai sociocultural context, the role of the teacher is often dominant in the classroom setting. The teacher is highly respected and revered as an authority figure, and their instructions are generally followed without question. Thai culture places a strong emphasis on hierarchy and respect for authority, and this is reflected in the dynamics of the classroom. Teachers in Thailand are typically seen as the primary source of knowledge and wisdom, and students are expected to show deference and obedience to their instructions. This hierarchical structure is deeply ingrained in Thai society and extends into the educational system, where the teacher is perceived as the central figure in the classroom (Graham, 2021). When participants reflected on their prior experiences in learning science, all of them said their teachers often gave lectures or wrote notes on the whiteboard. They did experiments by following the “cookbook” mostly. As they did not have much experience in doing hands-on activities, it seemed difficult for them to design STEM activities by themselves. Moreover, in Thai culture, questioning is sometimes regarded as a challenge to a teacher’s authority. In the past,

Thai students felt shy to ask questions even when they did not understand. They had few opportunities to express their ideas or have group discussions in class. The dominant role of the teacher in the Thai sociocultural context is deeply rooted in cultural values that prioritize respect for authority and hierarchy. The teacher is highly regarded as an influential figure in the classroom, and their instructions are followed with obedience and deference. These cultural dynamic shapes the educational environment in Thailand, and it is essential to understand the cultural context in order to effectively navigate and engage with the educational system (Prabjandee, 2019). This culture's effect on teaching and learning STEM, shows this teaching style is not common in Thailand, which means that many students have never had the opportunity to meet a good STEM teaching role model. This lack of exposure can have a detrimental impact on students' interest and achievement in these subjects. So, they think their prior learning experiences and the culture of science teaching shape their identities as a teacher and affect their perspectives of STEM teaching. However, they believed that STEM education is beneficial for Thai students' learning and valued John Dewey's "learning by doing" principle.

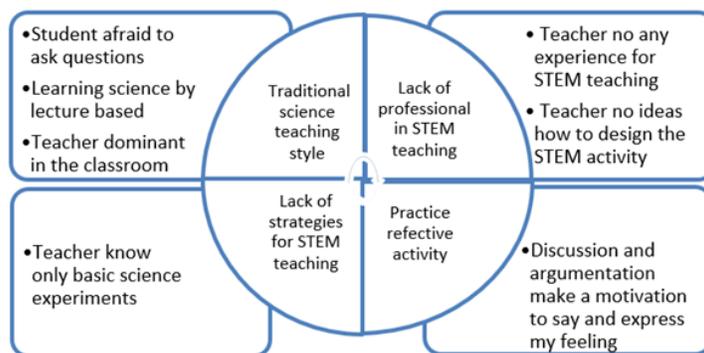
#### STEM teaching role models in Thai classroom

STEM education is crucial for students to develop the skills and knowledge needed for success in the 21<sup>st</sup> century. However, in Thailand, the focus of the education system has traditionally been on subjects such as biology, and chemistry, with less emphasis on STEM subjects. As a result, many students do not have access to high-quality STEM education and have never had the chance to encounter a teacher who is truly passionate and knowledgeable about these subjects. Without good STEM teaching role models, students may struggle to grasp the importance and relevance of STEM subjects in their lives. They may also lack the inspiration and motivation to pursue careers in STEM fields, which are becoming increasingly important in the global economy (Promboon et al.,2018).

Furthermore, the lack of exposure to good STEM teaching role models can perpetuate the idea that STEM subjects are difficult or uninteresting (Gladstone & Cimpian, 2021). This can lead to a self-perpetuating cycle where students are discouraged from pursuing STEM education and careers, further perpetuating the lack of representation in these fields. It is essential for Thailand to invest in and prioritize STEM education in order to provide students with the opportunity to encounter good STEM teaching role models. This can be achieved through professional development for teachers, increased resources and support for STEM education, and partnerships between schools and STEM industry professionals.

Effective STEM teaching requires teachers to take the role of a coach, a facilitator, and a co-researcher who guides students to ask questions, look for their own solutions, and co-construct knowledge together during inquiry (Hutton,2019). Cogen has a natural affinity with STEM learning because it is essentially a student-centered learning approach in which participants are given the opportunities to express their ideas and the autonomy to improve their learning experiences. Through Cogen, participants experienced the benefits of a student-centered learning approach and may be more motivated to carry out STEM projects in their classrooms. In addition, participants became more aware of their beliefs, values, and worldviews through critical self-reflection. Such awareness enhanced their empathy towards their students and prompted them to become more culturally responsive to students' needs. We propose that the synthesis of cogen and STEM education may catalyze a cultural shift in the Thai science learning environment.

### New knowledge from research



**Figure 1.** The model of STEM teaching and learning in Thai culture through co-generative dialogues summary

From co-generative dialogues in STEM teaching and learning in Thai culture, we found that, In the Thai sociocultural context, the traditional science teaching style such as learning from the textbook only, following activity from a cookbook, and the role of the teacher is often dominant in the classroom setting as a lecture-based are the obstacle for STEM teaching. The teacher is highly respected and revered as an authority figure, and their instructions are generally followed without question. The students are not familiar to express with their feeling and are afraid to ask questions. This culture's effect on teaching and learning STEM shows this teaching style is not common in Thailand. Moreover,

the lack of exposure to good STEM teaching role models can perpetuate the idea that STEM subjects are difficult or uninteresting in Thai sociocultural classrooms. Teachers need to know the strategies to teach STEM more than basic of simple experiments for make STEM classroom excitements. However, from the co-generative dialogs, participants experienced the benefits of a student-centered learning approach and may be more motivated to carry out STEM projects in their classrooms. Teachers need to add the discussion part and argumentation part to the STEM classroom. The discussion and argumentation will enhance the motivation for STEM learning and provide the chance for students to express their feelings and ideas that will create STEM intelligence skills.

## Summary

Fostering a democratic culture in STEM classrooms through regular co-generative dialogues allows students and teachers to act as co-researchers, sharing ideas freely in a non-judgmental environment. By exposing students to passionate and knowledgeable STEM teachers, Thailand can inspire the next generation of scientists, engineers, and innovators. This can help to close the gap in STEM education and ensure that all students have access to the skills and knowledge needed to succeed in the 21<sup>st</sup> century.

In conclusion, the lack of exposure to good STEM teaching role models in Thailand has significant implications for students' interest and achievement in STEM subjects. It is crucial for Thailand to prioritize and invest in STEM education in order to provide students with access to high-quality STEM teaching and to inspire the next generation of STEM professionals. By doing so, Thailand can ensure that all students have the opportunity to excel in STEM fields and contribute to the global economy and society.

One aspect of Thai culture that has influenced the worldviews and beings of its people is the emphasis on respect for authority and hierarchy. In Thai culture, individuals are taught to show deference to those in positions of authority, such as teachers or government officials. While this can lead to a strong sense of respect and obedience, it can also create challenges for individuals who want to become STEM teachers. This is because the traditional model of teaching in Thailand emphasizes rote learning and memorization, rather than critical thinking and problem-solving, which are essential skills for STEM education.

In conclusion, certain aspects of Thai culture have undoubtedly shaped the worldviews and beings of its people, and have both facilitated and hindered their ability to become STEM teachers. While the emphasis on respect for authority, collectivism, and the influence of Buddhism have brought valuable traits such as collaboration and compassion, they have also posed challenges in fostering critical thinking and innovation. As Thailand continues to strive for excellence in STEM education, it will be important to address these cultural influences and find ways to harness their strengths while overcoming their limitations. It is clear that a shift towards a student-centered approach is crucial for STEM education in Thailand. By nurturing a democratic classroom culture and promoting autonomous thinking, STEM teachers can support their students' learning and prepare them for success in the future. It is imperative that STEM teachers in Thailand embrace these recommendations to ensure that their students are equipped with the skills and knowledge needed to thrive in the ever-evolving world of science, technology, engineering, and mathematics

## Suggestions

Co-generative dialogues in STEM education reveal that traditional Thai teaching methods primarily textbook-driven and lecture-based—hinder effective learning. Teachers, seen as authoritative figures, dominate discussions, leading to student reluctance to express feelings or ask questions. This cultural dynamic fosters a perception that STEM subjects are difficult and uninteresting, compounded by a lack of positive role models.

To improve STEM education, teachers need to adopt co-generative dialogues in the STEM classroom, engaging with student-centered strategies beyond basic experiments. Incorporating discussion and argumentation in the classroom can boost student motivation and encourage them to express their ideas, ultimately developing important STEM skills.

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