Journal of Innovative Learning
Institute for Innovative Learning, Mahidol University

Research Article

2025: Vol. 1, No. 2, pages 62-72

Building STEM Education Capacity:

A Study of Thai Teachers' Network on Girls in ICT Day

Rangsun WIBOONUPPATUM[a]*, Jakkrapong JANTAWONG[b], Waiyawut THANABUT[c]

[a]*Education Specialist, UNICEF, Thailand*
[b]*Hang Dong Ratratuppatum, the Secondary Education Service area Office, Chiangmai, Ministry of Education, Thailand*
[c]*Wat Rajabopit School, The Secondary Educational Service Area Office Bangkok 1, Ministry of Education, Thailand*
*Corresponding author: rwiboonuppatum@unicef.org

Received: January 23, 2025; Revised: June 22, 2025; Accepted: June 30, 2025

Abstract: The STEM teachers networking in Thailand: Computational Thinking in STEM Education was launched during Girls in ICT Day 2023. The study had two objectives: to explore challenges in teaching STEM subjects (science, technology, engineering, and math) in Thailand, and to understand teachers' strategies and readiness for online child safety in digital learning due to the significant of ICT utilization in teaching and learning. A qualitative study involved 120 randomly selected teachers who attended the forum from May 2-3, 2023. They completed an anonymous online questionnaire. By the end, 81 teachers (mean age 37.7 years) responded—22 men (27.2%) and 59 women (72.8%). Male teachers had a median teaching experience of 8 years, while female teachers had 10 years. About 89% of participants understood STEM education well. Teachers found STEM most feasible to teach in science (60.5%), followed by engineering (30.9%), and math (8.6%). Male teachers were more likely to teach engineering than female teachers. Most teachers also showed good awareness and proactive efforts regarding online child safety, especially younger teachers. This study offers useful insights into Thailand's STEM education, emphasizing the need for digital skills, safe learning spaces, and balanced gender participation in STEM fields. Additionally, most teachers demonstrated awareness and proactive approaches to child safety online, especially among younger age groups. The study contributes valuable insights into Thailand's STEM education landscape, highlighting practical needs for digital competency, safe learning environments, and equitable gender representation in STEM fields.

Keywords: STEM, teacher network, computational thinking, Thailand

Introduction

The global Transforming Education Summit (TES), which was convened by the United Nations Secretary-General (UNSG) and held at the UN in September 2022, elevated education to the top of national and international political agendas. TES could mobilize action, cooperation, and solutions to reduce learning losses, address the learning crisis, transform educational systems, and revitalize momentum towards achieving sustainable development goal 4 (SDG4). As a result of TES, the UNSG released a vision statement titled "Transforming Education: An Urgent Political Imperative for Our Collective Future," which lay out the guiding principles for education in the twenty-first century. This emphasized the need to reconsider the goal and scope of education in order to achieve a truly transformative education that could respond to needs, cultures, and capacities at local, national, and global levels especially promoting the holistic development of all learners. While STEM (Science, Technology, Engineering, and Mathematics) is not a separate theme in the Transforming Education Summit (TES), it plays a critical role across key areas. First and foremost, STEM supports real-world problem-solving and prepares learners for future employment. In addition, it also emphasizes digital transformation, with STEM at the core of tech-driven curriculum innovation. Additionally, STEM is foundational in environment and climate education, particularly in promoting climate literacy through science and technology (UNESCO, 2022a)

As a United Nations affiliate member, the Thai Government has presented National Statement on Transforming Education on the world stage (the Royal Thai Government, 2022). The main critical themes in transforming education are to promote lifelong learning and enable cooperation among the state, local administrative organizations, and the private sector. Another crucial factor in education transformation is the creation of the right environment for learning in the digital age, which means using information and communication technology (ICT) as essential to promoting learning and developing learners' abilities with efficiency, equity, and equality. Moreover, they also focus on the adaptation of Thailand's education to the current situation, i.e., promoting the professional development of teachers, cooperating between stakeholders, adapting, and learning new technologies. Furthermore, the Thai government has appreciated the significance of digital technology and stands for the process of integrating digital transformation into their current learner-centered approach. It is proven that digital technology can improve the learning curve of students, who have to confront emerging challenges as a result of digital disruptions and rapidly changing technologies (Lewin et al, 2019). The statement emphasized that they would provide free, inclusive, and equitable access to online education through open-source platforms. They would be keen on a high-quality e-learning program, proper teacher preparation, and guarantee the safe use of digital technology and artificial intelligence. Such reforms will be a crucial tool for preparing people, training them, and enhancing the quality of life and skills needed in the twenty-first century to increase their potential and readiness to become Thai and global citizens of the future.

In this era, computational thinking (CT) is the thought process involved in formulating problems that can effectively be carried out by an information-processing agent. A study (Saidin et al, 2021) revealed the benefits of applying CT in teaching and learning processes. Another study was conducted by applying CT in the learning management model in pre-service teachers (Aumgri & Petsangsri, 2019). The outcome was learning achievement in the CT group was higher than the traditional method. Charting a Course for Success: America’s Strategy for STEM Education highlighted that building computational literacy is one of the four pathways to succeed in STEM education (Yin & Clippen, 2024). Thus, everyone could generally use CT, and it broadly affected the learning process in any field, although in STEM education.

Likewise, STEM education is a learning concept based on science, technology, engineering, and mathematics. As the resulting skills from STEM Education, not only do children learn the skills from STEM concepts, but they also receive practical application-based learning that encourages the development of a range of skill sets, including creativity and twenty-first-century competencies. Media and technology literacy, productivity, social skills, communication, flexibility, and initiative are twenty-first-century abilities. STEM education fosters a wide range of essential skills, including problem-solving, critical thinking, creativity, curiosity, decision-making, leadership, entrepreneurship, and the acceptance of failure. These skills are crucial for preparing students to navigate future careers and real-world challenges" (National Inventors Hall of Fame, 2023). Regardless of the future career path these children consider, these skill sets go a long way toward preparing them to be innovative.

In the festive of International Girls in ICT Day that is marked on the fourth Thursday of April each year throughout the world. It has emphasized on the lack of women's chances of pursuing careers in the Science, Technology, Engineering, and mathematics (STEM) sectors due to the unable to participate in digital environments and build their digital abilities. United Nations Children's Fund (UNICEF, 2023a) had a message in East Asia and Pacific Gender-Adolescent Newsletter JAN-MAR 2023 to raise awareness of the importance of girls in STEM. They persuaded every relevant organization to break down the barriers of the gender gap, such as gender inequity, by empowering, providing resources, giving advice, and inspiring adolescent girls with the stories of women who have made significant contributions to the STEM field (UNICEF, 2023b). Despite Thai girls outperforming boys in mathematics (by 16 points) and science (by 20 points) in PISA 2022, gender gaps in STEM aspirations persist. Few girls aim for STEM careers, with most high-performing girls favoring health fields. Only 3% of boys and 1% of girls aspire to ICT careers—despite rising demand—highlighting a disconnect between academic ability and future aspirations (OECD, 2023).

In order to promote girls' access to digital skills, empower girls in STEM, diminish educational inequity, ensure quality education, encourage lifelong learning, and support the national statement on transforming education, we determined to launch the activities on Girls in ICT Day Thailand 2023 by following the theme of "Computational Thinking in STEM Education." Hosted by Ministry of Education, UNICEF, and International Telecommunication Union (ITU).

Objectives

The study had two objectives: 1) to explore challenges in teaching STEM subjects (science, engineering, and math) in Thailand, and 2) to understand teachers' strategies and readiness for online child safety in digital learning due to the significant of ICT utilization in teaching and learning.

Methodology

A qualitative and descriptive study of teachers participating in Girls in ICT Day 2023 under the theme "Building STEM Education Capacity: A Study of Thai Teachers' Network on Girls in ICT Day" was conducted in 2023. The teacher's inclusion criteria were any teachers currently teaching at secondary schools in any subject in relation to STEM without the restriction of any jurisdiction of teaching, private or government schools, and willing to share and listen to colleagues' experiences. Because of The previous forum, Girls in ICT Day 2022, included only female teachers, we therefore included male and female teachers in the cohort. After the subscription period, there were about 668 applicants for the programme, the participants were randomly selected 120 participants equally distributed to represent 4 regions (30 each): north, south, northeast, and central of Thailand.

The study cultivated from the forum, STEM teachers networking in Thailand: Computational thinking in STEM, was launched by UNICEF Thailand with the collaboration of many agencies such as the Bureau of Information and Communication Technology (BICT); Office of the Permanent Secretary (OPS), the Bureau of Teaching and Learning Technology (BTLT); OBEC, Office of Education Region15, including the Institute of Promoting Science and Technology (IPST) as well as International Telecommunication Union (ITU). From May 2-3, 2023, the activities were an online virtual meeting and discussion with Thai STEM teachers and professional speakers. During the discussion and networking activities, all participants were separated into four focus groups to allow adequate time for interaction and exchanging ideas.

At the end of the activity, all participants were required to answer the questionnaire by using an electronic form with an anonymous user. The questionnaire consisted of three parts. The first part is demographic data, including sex, age, school region, subject area, teaching level, and teaching experience. Secondly, we analyzed Computational Thinking in STEM by collecting the comprehension and feasibility of applying STEM. The perception and bias about sex with STEM careers were collected. Questionnaires were reviewed by three experts in STEM fields and five teacher peers. The quality of the items was assessed using the Index of Item-Objective Congruence (IOC), with values ranging between 0.80 and 1.00, indicating high content validity. We compared the confidence level of STEM applications before and after the forum by collecting confidence scores ranging from 1 to 5 (1 = least confidence, 5 = most confidence). Lastly, participants also have opportunities to address recommendations.

Using directed content analysis (Hsieh & Shannon, 2005), gathered data was reviewed through four steps: (1) identifying predefined categories (e.g., policy reform, teacher training, equity), (2) coding manifest content, (3) clustering related phrases, and (4) interpreting meaning in context. The analysis revealed a global policy narrative emphasizing digital inclusion, stakeholder partnerships, and education system renewal, aligned with Sustainable Development Goal 4.

Baseline demographic data were presented as frequency and percentage for categorical variables, mean and standard deviation (SD), or median and interquartile range (IQR) for continuous variables. A qualitative study was performed by content analysis.

Results

From online workshop during May 2-3, 2023, a total of 100 teachers participating in Girls in ICT Day 2023 under the theme "STEM Teachers Networking in Thailand: Computational Thinking in STEM". Only eighty-one participants answering the questionnaire, mean age of 37.7 years, were at the end of the study. (Figure 1)

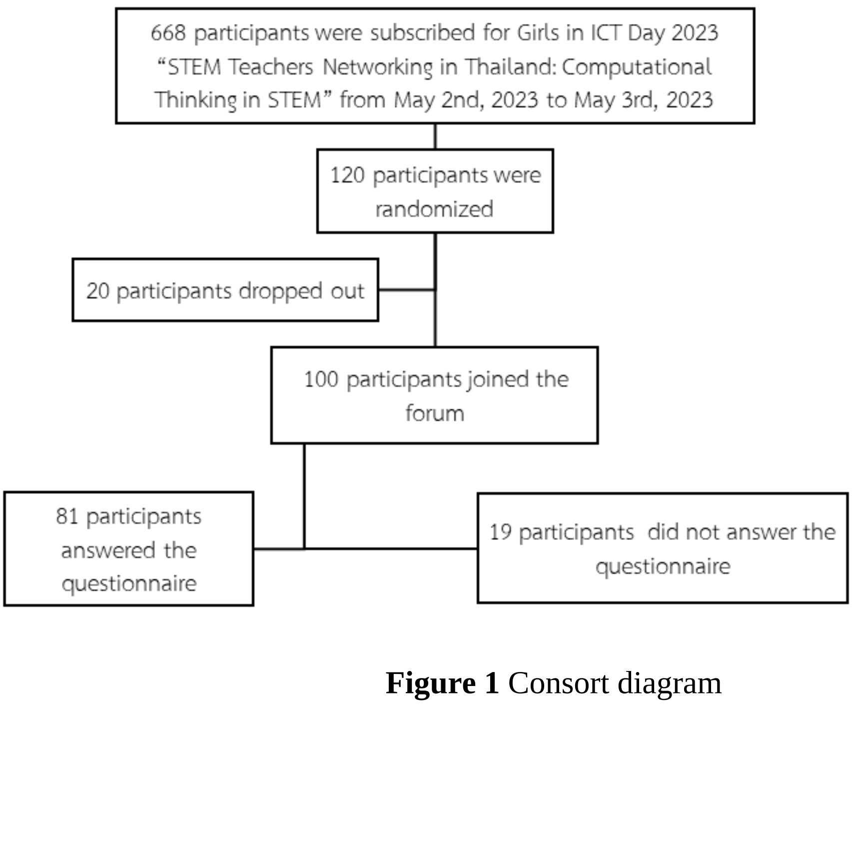

Figure 1 Consort diagram

Most of the participants were female. There were 22 (27.2%) and 59 (72.8%) in male and female groups, consecutively. The mean age of the female teacher group was slightly older than the male teacher group at 38.5 ± 1.2 and 35.6 ± 1.9 years old. The participants from the central region were 33 (40.7%). Science was the most subject area that participants taught. Only 5 (6.2%) participants taught in all subject areas. In the male teacher group, 3 (13.6%) taught in the other subject area. Both male and female teacher groups were similar in high school teaching level at 59.1% and 57.6%. The teaching experience differed in male and female teacher groups for 2 years (median 8.0 IQR 3.0 to 15.0 in the male teacher group and median 10.0 IQR 5.0 to 20.0 in the female teacher group (Table 1).

Table 1 Demographic data

Aspect	Total N = 81	Male teacher group 22 (27.2%)	Female teacher group 59 (72.8%)
Age; mean ± SD	37.7 ± 9.1	35.6 ± 1.9	38.5 ± 1.2
School region; n (%)			
- Central	33 (40.7%)	9 (40.9%)	24 (40.7%)
- North	15 (18.5%)	7 (31.8%)	8 (13.6%)
- South	15 (18.5%)	3 (13.6%)	12 (20.3%)
- Northeast	11 (13.6%)	3 (13.6%)	8 (13.6%)
- East	4 (4.9%)	0 (0%)	4 (6.8%)
- West	3 (3.7%)	0 (0%)	3 (5.1%)
Subject area			
- Science	58 (71.6%)	14 (63.6%)	44 (74.6%)
- Mathematics	15 (18.5%)	3 (13.6%)	12 (20.3%)
- All	5 (6.2%)	2 (9.1%)	3 (5.1%)
- Others	3 (3.7%)	3 (13.6%)	0 (0%)
Teaching level			
- Elementary school	23 (28.4%)	6 (27.3%)	17 (28.8%)
- Junior high school	26 (32.1%)	5 (22.7%)	21 (35.6%)
- High school	47 (58.0%)	13 (59.1%)	34 (57.6%)
Teaching experience (year); median (IQR)	10.0 (5.0, 16.5)	8.0 (3.0, 15.0)	10.0 (5.0, 20.0)

To evaluate comprehension in Computational Thinking in STEM, the participants had to describe the component of the subject area in STEM education—72 (88.9%) of the participants correctly described it. The feasibility of applying STEM education is 49 (60.5%), 25 (30.9%), and 7 (8.6%) in Science, Engineering, and Mathematics, consecutively. In the male teacher group, the feasibility of applying STEM education in engineering was higher. There was 36.4% compared with 28.8% in male and female teacher groups. A chi-square test was conducted to examine differences in subject preferences (Science, Engineering, Mathematics) among all participants, male teachers, and female teachers. The results showed no statistically significant difference, $\chi^2(4, N = 81) = 0.48$, $p = .975$. This suggests that the distribution of preferences across the three groups is similar, with science being the most preferred subject in all groups. (Table 2)

Table 2 The feasibility of applying STEM education in class

Aspect	Science	Engineering	Mathematics
All participants	49 (60.5%)	25 (30.9%)	7 (8.6%)
Male teacher group	12/22 (54.5%)	8/22 (36.4%)	2/22 (9.1%)
Female teacher group	37/59 (62.7%)	17/59 (28.8%)	5/59 (8.5%)

The perception of the opportunity for success in STEM careers between gender had no difference between the male and female teacher groups. In terms of the perception of the effect of gender, bias, and norm on STEM careers, both male and female teacher groups had similar perceptions. (Figure 2A and 2B) There were 72.7% and 78.0% in the male and female teacher groups. Only 19.8% of all participants precepted that gender, bias, and norm had an effect on STEM careers. (Figure 2B)

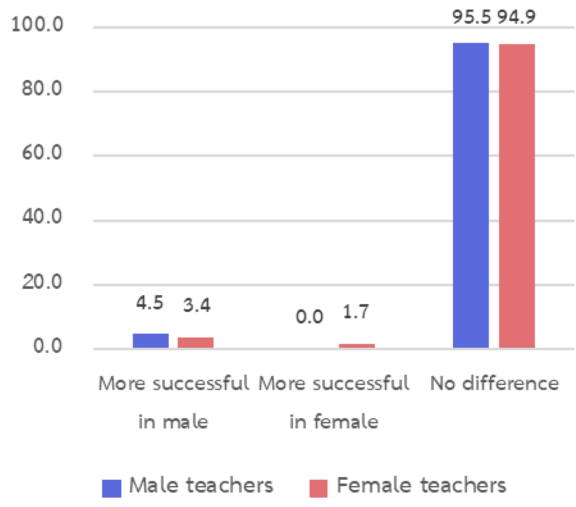

Figure 2A

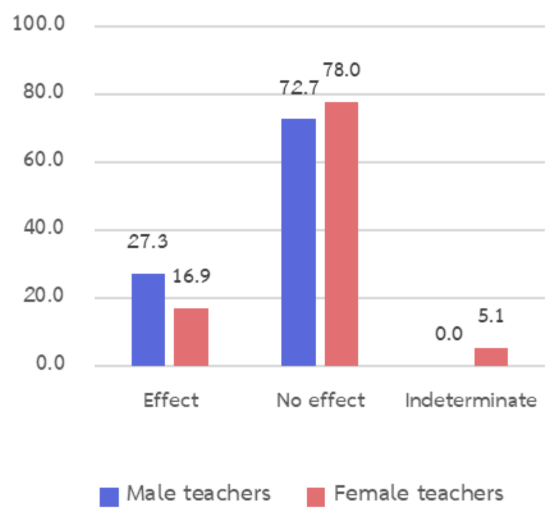

Figure 2B

Figure 2 Perception in STEM careers. Perception of the opportunity for success in STEM careers between gender (2A); Perception of the effect of gender, bias, and norm on STEM careers (2B)

Before the forum, most male and female teachers had a confidence level of medium confidence, 15 (18.5%) and 29 (35.8%), consecutively. There were 10 (12.3%) female teachers with more and the most confidence at the start. After completion of the forum, both male and female teachers unidirectionally improved in confidence levels. Almost all participants had a more and more confidence level, 20 (27.6%) in male teachers and 55 (67.9%) in female teachers. A phi test was conducted to examine the association between gender (male vs. female) and increased confidence levels after the forum. The results showed a significant association, $\chi^2(1, N = 109) = 11.28$, $p = .001$, with a phi coefficient of 0.29, indicating a moderate effect size. This suggests that female teachers were more likely than male teachers to report higher confidence levels following the forum. (Figure 3)

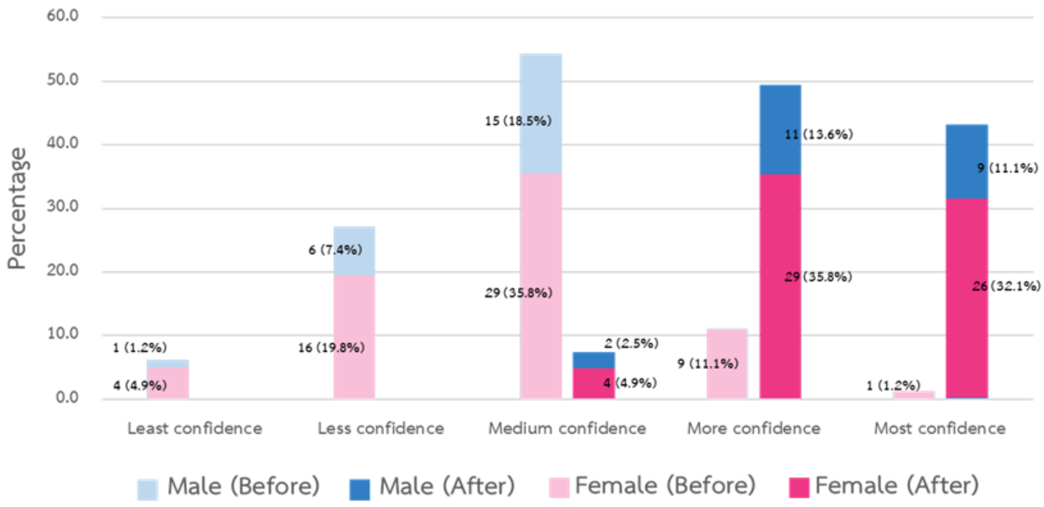

Figure 3 The comparison of confidence level in the application of Computational Thinking in STEM Education

Due to the participants being teachers from different school levels; primary, secondary, and vocational levels, the safe-to-learn concept has been infused in the workshop so that teachers would take a comprehensive framework to ensure that students are well taken care of mental, physical, cognitive, and value aspects. Teachers have reported on their perspectives toward Child Safety Online issues in the following table. A chi-square test was conducted to examine the relationship between teachers' sex and whether they had counseled students on child safety online. The result showed no significant association, $\chi^2(1, N = 81) = 0.02$, $p = .88$. This suggests that male and female teachers were equally likely to have provided counseling on child safety online.

Moreover, a chi-square test was applied to assess whether teaching level (elementary, junior high, high school) was associated with providing counseling on child safety online. The result was also not significant, $\chi^2(2, N = 96) = 0.37$, $p = .83$, indicating no meaningful difference in counseling behavior across teaching levels. (Table 3)

Table 3 Child Safety Online

Aspect	**Counseling 56 (69.1%)**	**Never counseling 25 (30.9%)**
Sex		
- Male	16/22 (72.7%)	6/22 (27.2%)
- Female	40/59 (67.8%)	19/59 (32.2%)
Age; mean ± SD	38.2 ± 1.1	36.8 ± 2.2
Teaching level		
- Elementary school	15 (26.8%)	8 (32.0%)
- Junior high school	19 (33.9%)	7 (28.0%)
- High school	33 (58.9%)	14 (56.0%)

There were 56 of 81 (69.1%) teachers that have experience in counseling students in the aspect of Child Safety Online. The mean age of teachers that ever give counseling was 38.2 ± 1.1 years old. Most of them were teaching at high school levels at 58.9%. When stratified by age group, the range of 31 to 40 years old teachers had the most frequent Child Safety Online counseling. The Chi-square test results indicate no significant association between age group and counseling behavior regarding Child Safety Online ($\chi^2(3) = 3.61$, $p = 0.31$). This suggests that the likelihood of teachers counseling students on Child Safety

Online does not significantly differ across various age groups. Therefore, age does not appear to be a determining factor in whether teachers provide counseling on this issue. (Table 4)

Table 4 Child Safety Online: stratified by age group

Age group	Counseling 56 (69.1%)	Never counseling 25 (30.9%)
Below 30 years old	11 (19.6%)	9 (36.0%)
31-40 years old	23 (41.1%)	8 (32.0%)
41-50 years old	18 (32.1%)	5 (20.0%)
51-60 years old	4 (7.1%)	3 (12.0%)

Table 5 showed the solution strategies for Child Safety Online. The most selected strategy in coping with Child Safety Online was "Consult with the student's parents and other teachers to solve the problems together", "Report to MOE Safety Center", and "Report to a school administrator", consecutively.

Table 5 The solution strategies for Child Safety Online

Solution strategies	Number of teachers
1. Consult with the student's parents and other teachers to solve the problems together	48 (59.3%)
2. Report to a school administrator	10 (12.3%)
3. Report to MOE Safety Center	13 (16.0%)
4. Report to cyber police	2 (2.5%)
5. Call 1212 (Online Complaint Center)	2 (2.5%)
6. Contact the non-governmental organizations (NGOs) working in the field of child protection	1 (1.2%)
7. Others	5 (6.2%)

Conclusion and Recommendations

After completion of the forum, both male and female educators reported higher confidence levels following the workshop, with female teachers demonstrating a more pronounced increase. Most teachers identified science as the most feasible subject for STEM integration (60.5%), followed by engineering (30.9%) and mathematics (8.6%). While male teachers showed a slightly higher inclination toward applying engineering concepts, there was no statistically significant difference in subject preferences by gender. Perceptions regarding gender equity in STEM careers were largely positive among participants, though these perceptions may reflect the self-selected nature of the cohort rather than broader national trends. The male teacher group was prone to apply engineering in class at a higher proportion than the female teacher group. There were no previous studies collecting these data. By the way, men shared held the more proportion of STEM careers in part of the Engineering and technology field. This might be implied that male teachers could have more feasibility of applying engineering in class.

Perception of the opportunity for success in STEM careers had no difference between gender and there was no effect of gender, bias, and norm on STEM careers in both male and female teacher groups. Despite Thai girls outperforming boys in mathematics and science, few girls aspire to STEM careers, which aligns with the findings of the UNICEF report (2023). The report emphasizes that gender gaps in STEM education and careers remain a significant issue, with women being underrepresented in STEM fields. This underrepresentation is attributed to various factors, including societal norms, biases, and limited opportunities for girls to build digital skills and pursue STEM careers. This finding underscores the need for initiatives to promote gender equity in STEM education and careers, supporting the broader goals outlined by UNICEF (2023). This dissimilarity between UNICEF's data and our results might be caused by the participants. This forum did not recruit the normal population of the participants, the participants joined by their interests. Thus, the female group of this cohort might have more leadership and perception of the equity of gender.

To strengthen STEM education in Thailand, professional development for teachers should prioritize integrating computational thinking across all STEM subjects, especially in mathematics and engineering where confidence remains lower. Gender-responsive strategies—such as mentorship and awareness programs—are essential to address persistent gender gaps in STEM aspirations. Expanding STEM into STEAM by incorporating the arts can foster creativity and innovation. Engaging school administrators and tailoring approaches to regional contexts will enhance adoption and impact. The administrator strategic leadership is critical for integrating computational thinking across all STEM subjects (Day & Summon, 2016), particularly in promoting teacher confidence. Moreover, by actively supporting gender-responsive strategies and the expansion of STEM into STEAM, administrators can foster an inclusive and innovative learning environment (Villiant, 2015). Tailoring these approaches to regional contexts and aligning them with national education transformation goals will ensure that all learners benefit from equitable, inclusive, and future-ready STEM education. Therefore, school leadership and commitment are vital to making these transformative changes a reality. These efforts should align with national education transformation goals, ensuring equitable, inclusive, and future-ready STEM education for all learners across the country.

Ensuring child online protection creates a safe digital learning environment, which is essential for effective STEM education. When students feel secure online, they are more likely to engage actively and positively in their learning activities (UNICEF, 2023). Moreover, STEM education often involves significant use of digital tools and resources. Protecting children online helps foster a secure space where they can develop digital literacy and other essential skills without the risk of exposure to harmful content or cyber threats. In terms of Child Safety Online, we have found that 56 of 81 (69.1%) teachers have experience in counseling students in the aspect of Child Safety Online. Teachers who were 31 to 40 years old had the most frequent counseling. We hypothesized that the younger the age, the lower the confidence in the students. In contrast, the older teachers' group might not understand their problems due to the generation gap. Furthermore, we have discovered that the teachers solve the problems with their capabilities by consulting with the student's parents and other teachers to solve the problems together.

If all schools systematically manage the practical Child Safety Online, the teachers will solve the problems more effectively. These may provide schools with the accountability and reliability system of the Child Safety Online protection strategies in school productively. To ensure safe digital learning in STEM and STEAM education, schools should integrate child online protection into teaching practices and curricula. Clear protocols for reporting and responding to online risks must be established and communicated to teachers. Governments around the world are increasingly acknowledging the threat of online child sexual exploitation and abuse, and some countries have taken steps to introduce the necessary legislation and put protective measures in place to safeguard children online." (UNICEF, 2022, p. 35). Digital citizenship should be taught alongside STEM content, empowering students to navigate technology responsibly. Collaboration among educators, parents, and agencies is vital to building a secure, supportive environment for digital learning and innovation.

Implication

For further studies, we suggest that the researchers could conduct the research by adding the A (Art) field in STEAM education and recruit more participant groups, such as the school administrators, for more perspective and experiences. These may provide more applicable data to effectively establish a trendy and sustainable process of computational thinking in STEM in school. Moreover, partnerships with arts educators or institutions, Piloting administrator workshops or roundtables, Curriculum integration models that combine CT and creative expression.

References

Aumgri, C., & Petsangsri, S. (2019). *Computational thinking for preservice teachers in Thailand: A confirmatory factor analysis*.

Day, C., & Sammons, P. (2016). *Successful school leadership. Education Development Trust*. Retrieved from https://files.eric.ed.gov/fulltext/ED565740.pdf

Hsieh, H. F., & Shannon, S. E. (2005). *Three approaches to qualitative content analysis*. *Qualitative Health Research, 15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Lewin, C., Smith, A., Morris, S., & Craig, E. (2019). *Using digital technology to improve learning: Evidence review. Education Endowment Foundation*. Retrieved from https://files.eric.ed.gov/fulltext/ED612157.pdf

Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2020). Computational thinking is more about thinking than computing. *Journal for STEM Education Research, 3*(1), 1–18. https://doi.org/10.1007/s41979-020-00030-2

National Inventors Hall of Fame. (2023). *What is the value of STEM education?* Retrieved from https://www.invent.org/blog/trends-stem/value-stem-education

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/4ddbbfa5-en

Pimdee, P., & Pipitgool, S. (2023). Promoting undergraduate pre-service teacher computational thinking. *TEM Journal, 12*, 540–549. https://doi.org/10.18421/TEM121-64

Saidin, N. D., Khalid, F., Martin, R., Kuppusamy, Y., & Munusamy, N. (2021). Benefits and challenges of applying computational thinking in education. *International Journal of Advance Computer Science and Applications, 7*(1), 2158-107X. Retrieved from https://www.ijacsa.com/uploads/6809995cae24c_1745459548.pdf

Swaid, S. I. (2015). Bringing computational thinking to STEM education. *Procedia Manufacturing, 3*, 3657–3662. https://doi.org/10.1016/j.promfg.2015.07.761

The National Inventors Hall of Fame. (n.d.). *What is the value of STEM education*. Retrieved April 10, 2023, from https://www.invent.org/blog/trends-stem/value-stem-education

The Royal Thai Government. (2022). *National statement of the Royal Thai Government on transforming education*. Retrieved April 23, 2023, from https://transformingeducationsummit.sdg4education2030.org/system/files/2022-09/Thailand_National%20Statement%20of%20Commitment.pdf

UNESCO (2022a). *Transforming Education Summit: UNESCO rallies coalitions for change*. https://www.unesco.org/en/articles/transforming-education-summit-unesco-rallies-coalitions-for-change

UNESCO (2022b). *Transforming education now and for the future we want*. Retrieved April 23, 2023, from https://bangkok.unesco.org/content/transforming-education-now-future-we-want-tes-national-follow-actions-move-towards-

UNICEF. (2022). *Disrupting Harm in Thailand: Evidence on online child sexual exploitation and abuse. Global Partnership to End Violence Against Children*. Retrieved from https://www.unicef.org/thailand/media/8436/file/Disrupting%20Harm%20in%20Thailand%20EN.pdf

UNICEF. (2023a). *East Asia and Pacific Gender-Adolescent Newsletter: January–March 2023*. Retrieved April 17, 2023, from https://mailchi.mp/766c7696326b/east-asia-and-pacific-gender-and-adolescent-newsletter?e=0e23bd57eb

UNICEF. (2023b). *Mapping gender equality in STEM from school to work*. Retrieved May 12, 2023, from https://www.unicef.org/globalinsight/stories/mapping-gender-equality-stem-school-work

UNICEF. (2023c). *Child online protection in and through digital learning*. Retrieved from https://www.unicef.org/eca/media/22501/file/Child%20Online%20Protection%20in%20and%20through%20Digital%20Learning.pdf

Vaillant, D. (2015). *School leadership, trends in policies and practices, and improvement in the quality of education*. Background paper prepared for the Education for All Global Monitoring Report 2015, Education for All 2000-2015: achievements and challenges. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000232403

Yun, Minji & Crippen, Kent. (2024). Computational Thinking Integration into Pre-Service Science Teacher Education: A Systematic Review. J*ournal of Science Teacher Education, 36*. 1-30.