INTERNATIONAL STEM EDUCATION CONFERENCE 2024 SINGAPORE

With-In and In-With STEM Education Research

26-28 June 2024

National Institute of Education
Nanyang Technological University
Singapore

Programme Book

NIE NATIONAL INSTITUTE OF EDUCATION SINGAPORE

An Institute of

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

ISTEM-ED 2024

Theme: With-In and In-With STEM Education Research

In the last decade, integrated STEM education research has emerged as a relatively new field in education studies. While most academic scholars are not trained in integrated STEM education, many of them have straddled between disciplinary-based education research and STEM education research. The latter presents many exciting new inspirations and opportunities for the individual disciplines to be designed, enacted, assessed, evaluated, theorised, and researched. "With-in" refers to the emergence of integrated STEM education research from within the monodisciplinary education research as academic scholars bring their knowledge from science education, engineering education, mathematics education, and technology education to construct new understandings in this emerging field. "In-with" suggests the collective efforts of the academic scholars working together to legitimise integrated STEM education as an independent field of study informed by robust research and undergirded by theories. This conference is a platform for researchers to be part of the exciting journey in co-constructing their identity as integrated STEM education researchers.

Table of Contents

Message from ISTEM-ED 2024 Conference Chairpersons

STEM (science, technology, engineering and mathematics) education research has gained traction in the recent decade. While the acronym was coined in the United States, other parts of the world have embarked on STEM education based upon their interpretations of the goals, purposes, and approaches of STEM teaching, learning, assessment and evaluation in their own local contexts. The recent publication "STEM Education from Asia: Trends and Perspectives", coedited by members of the Multi-centric Education, Research and Industry STEM Centre at the National Institute of Education (meriSTEM@NIE), illuminates STEM education efforts and interpretations in the largest continent.

As a STEM education research centre of a national teacher education institute and research-based University, meriSTEM@NIE aims to expand its existing work on STEM teacher capacity building in the region. We created ISTEM-ED as a professional platform for academics, scholars, researchers, teachers, and policy makers to dialogue about STEM pedagogies, teachers, students, teaching and learning, history, cultures, assessment, evaluation, methodologies, theories, and so on. We welcome and strongly encourage your participation to join as a member of ISTEM-ED research fraternity.

The recent COVID pandemic has catalyzed and propelled the digital transformations of economies and education. Although we have now entered the endemic phase of the COVID-19 crisis, educators find themselves on new grounds in education. Particularly for STEM education, STEM educators are pressed even more to think more deeply about STEM curricula, STEM learning, and innovative teaching approaches in STEM for the purpose of preparing our digital natives for the fifth industrial revolution.

The inaugural conference ISTEM-ED 2024, with the theme 'With-In and In-With STEM Education Research,' aims to provide a platform for intellectual dialogue on these issues related to STEM education.

The objectives of the conference are to:

(a) provide a platform for experts to share and exchange best practices in STEM education and STEM education research;

(b) foster networking and collaborations with Ministry of Education (MOE) colleagues and overseas participants; and

(c) build local capacity among faculty, mathematics, and science teachers in STEM education research.

We believe that this conference will not only strengthen our understanding of STEM education but will also spark new STEM-related initiatives and grow new STEM-education networks and collaborations in the region and beyond. On that note, we wish everyone a very productive conference ahead.

Associate Professor TEO Tang Wee

Assistant Professor CHOY Ban Heng

Co-chairs, ISTEM-ED 2024 Organising Committee

Co-heads, meriSTEM@NIE

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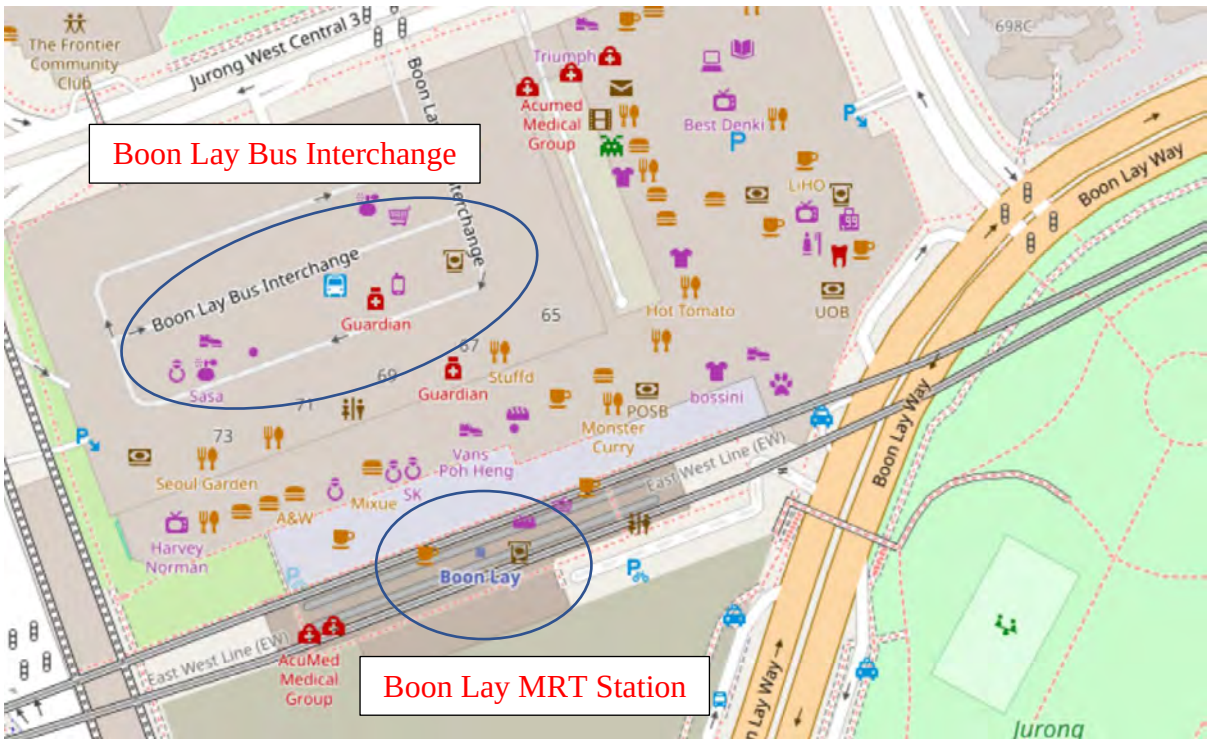
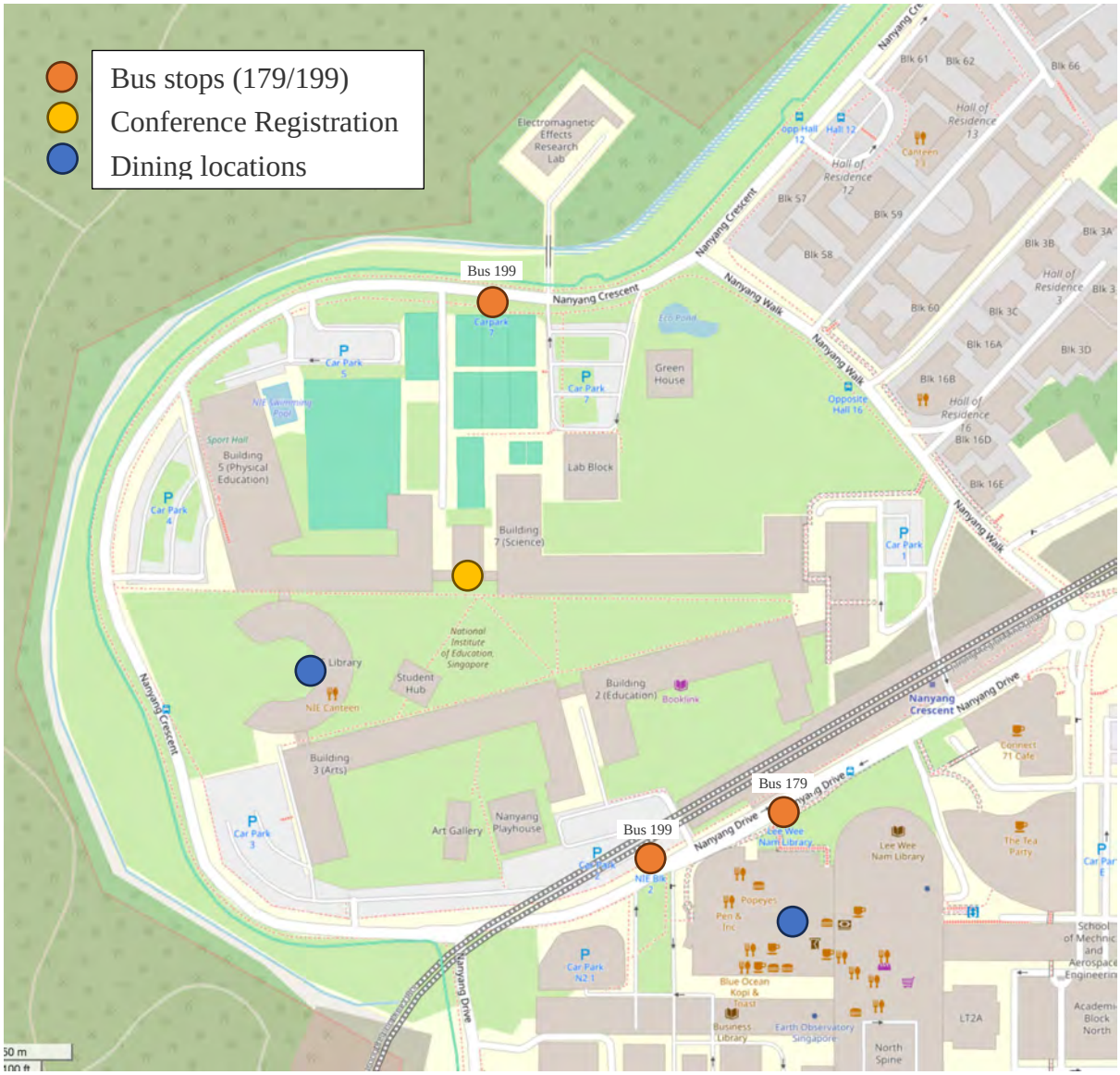
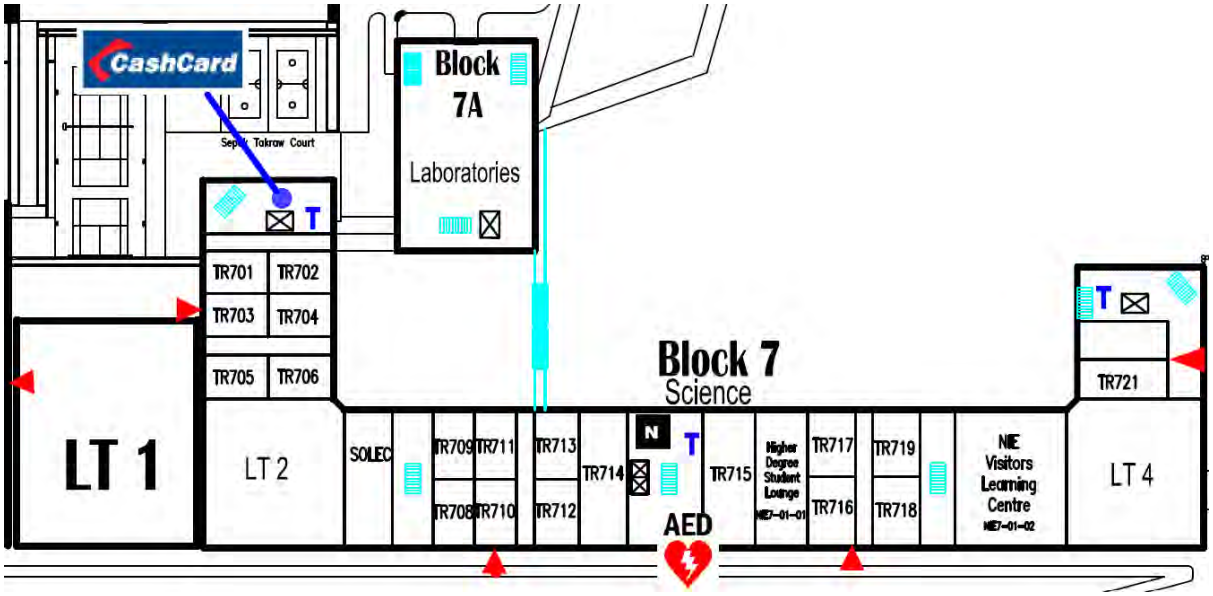
MRT	Find your way to Boon Lay MRT station (East-West line, station EW27), then proceed by bus.
Bus	From Boon Lay bus interchange, take either bus service 199 or 179. Alight at the bus stop outside Block 7 (bus 199), outside Block 2 (bus 199), or opposite Block 2/on NTU side (bus 179).
Taxi	Taxis to NIE generally cost around S$30 from hotels situated near the main commercial district around Orchard Road to Marina Bay. If you are taking a taxi from campus, it is advisable to use a ride hailing app to call a taxi (select NIE Blk 1 as pick-up point) as taxis do not frequent the campus.
Ride Hailing Services	Download app from: Comfort Taxi: https://www.cdgtaxi.com.sg/ride-with-us/ Grab: https://www.grab.com/sg/download/ Gojek: https://www.gojek.com/sg
Self-Drive	Parking facilities are available on campus (refer to NIE map on next page for carpark locations). Parking fees apply.



NIE Maps


Bus stops (179/199)
Conference Registration
Dining locations
Bus 199
Bus 179
Bus 199
Nanyang Crescent
Nanyang Walk
Nanyang Drive
Electromagnetic Effects Research Lab
Hall of Residence 12
Hall of Residence 13
Hall of Residence 3
Hall of Residence 16
Green House
Lab Block
Building 7 (Science)
Building 5 (Physical Education)
Sport Hall
Library
Student Hub
NIE Canteen
National Institute of Education Singapore
Building 2 (Education)
Booklink
Building 3 (Arts)
Art Gallery
Nanyang Playhouse
Lee Wee Nam Library
Opposite Hall 16
Blk 57
Blk 58
Blk 59
Blk 60
Blk 61
Blk 62
Blk 66
Blk 3A
Blk 3B
Blk 3C
Blk 3D
Blk 16A
Blk 16B
Blk 16D
Blk 16E
Car Park 1
Car Park 2
Car Park 3
Car Park 4
Car Park 5
Car Park 7
Car Park N2.1
NIE Blk 2
Connect 71 Cafe
The Tea Party
Popeyes
Blue Ocean Kopi & Toast
Business Library
Earth Observatory Singapore
LT2A
North Spine
50 m

NIE Location Map (Block 7 and Block 7A)



Link to full map: https://www.ntu.edu.sg/docs/nielibraries/corporate/main-campus-map-june-2023.pdf?sfvrsn=97230667_3

Registration

- All participants will register at the registration desk located outside **Lecture Theatre 1 (LT1)** (refer to NIE map on p. 9) on **27 Jun 2024** from **0800 to 0900** to collect their name tag and meal vouchers.
- Name tags are to be worn throughout the conference and at meal times.
- If you missed the registration window, please proceed to the Conference Secretariat Room located at **Tutorial Room TR714** (refer to NIE map on p. 9) to register.
- If you have any other enquiries, the Conference Secretariat Room at TR714 will be open during the following timing:

  26 Jun 2024 from 1230 to 1700
  27 Jun 2024 from 0900 to 1730 (Conference Secretariat will be at the registration desk outside LT1 from 0800-0900)
  28 Jun 2024 from 0830 to 1730

  Alternatively, you can email the Conference Secretariat at istem-ed2024@nie.edu.sg.

Lunch and Tea Break

All food served is Halal. Participants are entitled to one packed meal box per lunch/tea break. To collect the meal boxes, participants will need to present the meal vouchers found at the back of their name tag. Please do not lose the meal vouchers as they are not replaceable.

Programme Overview

<table>
<tr><th>Time</th><th>Day 1 (Wed)
26 June 2024</th><th>Day 2 (Thur)
27 June 2024</th><th>Day 3 (Fri)
28 June 2024</th></tr>
<tr><td>0900 - 0930</td><td rowspan="8"></td><td rowspan="2">Welcome Ceremony
LT1</td><td rowspan="3">Keynote 2
Prof Jinwoong Soong
LT1</td></tr>
<tr><td>0930 - 1000</td></tr>
<tr><td>1000 - 1030</td><td rowspan="3">Keynote 1
Prof Gillian Roehrig
LT1</td></tr>
<tr><td>1030 - 1100</td><td>Tea Break</td></tr>
<tr><td>1100 - 1130</td><td rowspan="3">Keynote 3
Ast/P Choy Ban Heng
LT1</td></tr>
<tr><td>1130 - 1200</td><td rowspan="2">Lunch and Poster Session (outside LT1)</td></tr>
<tr><td>1200 - 1230</td></tr>
<tr><td>1230 - 1300</td><td rowspan="2">Concurrent Session 1
various venues</td><td rowspan="2">Lunch and Poster Session (outside LT1)</td></tr>
<tr><td>1300 - 1330</td></tr>
<tr><td>1330 - 1400</td><td rowspan="5">Pre-conference Workshops
(Concurrent Sessions) and Tea-break
[for registered workshop participants only]</td></tr>
<tr><td>1400 - 1430</td><td>Tea Break</td><td rowspan="2">Concurrent Session 4
various venues</td></tr>
<tr><td>1430 - 1500</td><td rowspan="2">Concurrent Session 2
various venues</td></tr>
<tr><td>1500 - 1530</td></tr>
<tr><td>1530 - 1600</td><td rowspan="3">Keynote 4
Prof Lyn D. English
LT1</td></tr>
<tr><td>1600 - 1630</td><td rowspan="3">Concurrent Session 3
various venues</td></tr>
<tr><td>1630 - 1700</td><td rowspan="2"></td></tr>
<tr><td>1700 - 1730</td><td>Closing Ceremony
LT1</td></tr>
</table>

Detailed Programme

Please refer to the online ISTEM-ED 2024 programme:

https://bit.ly/4aUeetO

PROGRAM FOR WEDNESDAY, JUNE 26TH

13:30-16:30 Session PCW1: Ticketed Workshop

Pre-conference Workshop by Keynote Speaker Gillian Roehrig [Ticketed]

Characteristics of High Quality Integrated STEM Curriculum

In this workshop, participants will learn about the characteristics of quality integrated STEM curriculum through the K-12 Integrated STEM Framework (Roehrig et al., 2021). This framework builds upon the extant integrated STEM literature to describe seven central characteristics of integrated STEM: (a) centrality of engineering design, (b) driven by authentic problems, (c) context integration, (d) content integration, (e) STEM practices, (f) twenty-first century skills, and (g) informing students about STEM careers. The integrated STEM framework is intended to provide more specific guidance to educators about the curriculum development and implementation. The framework will be illustrated by engaging participants in an exemplar integrated STEM curriculum. Participants will engage in some of the hands-on activities and reflect on the activities using the Integrated STEM Framework.

LOCATION: 7A-01-06

13:30-16:30 Session PCW2: Ticketed Workshop

Pre-conference Workshop by Keynote Speaker Lyn D. English [Ticketed]

Exploring and Developing STEM-based Problems that Challenge Students' Thinking

This *International STEM Education* workshop will comprise four components as follows:

1. a brief review of traditional problem solving where problems tend to be closed, have only one correct answer, and require the application of previously taught procedures. These problems tend not to promote different ways of thinking or encourage development of new concepts.
2. a brief consideration of why traditional problem solving is inadequate for today's rapidly changing world.
3. an overview of different ways of thinking, to be addressed more fully in the plenary.
4. exploration of interactive STEM-based problems that encourage both disciplinary knowledge growth and application, and different ways of thinking. It is envisaged that participants will engage in working a sample of such problems, together with designing their own

examples. Included in this component will be shared ideas on assessing students' responses.

If possible, it would be helpful if participants could bring samples of problems implemented in their classrooms/school systems. These could be explored during the workshop and adapted to encourage more challenging problem solving and thinking skills.

LOCATION: 7A-01-07

13:30-16:30 Session PCW3: Ticketed Workshop

Pre-conference Workshop by Keynote Speaker Jinwwong Song [Ticketed]

Developing informal STEAM programmes for scientific engagement and practice: Lessons from the 'Doing Science, the Gangnam Style' project

In many countries, including Korea, STE(A)M education activities are still limited to the school education environment. As modern society changes into a life-long learning society, the scene of STE(A)M education also needs to take place in the context of non-formal education settings. In particular, in a future society where 'scientific participation and practice' is emphasized more and more, a key question becomes what kind of STEM learning experience not only for students but also for citizens need. In this workshop, how to develop an informal STEAM education program for 'scientific participation and practice' is going to be discussed, based on the experience of operating 'Doing Science, the Gangnam Style' Project, a university-community collaborative STEAM education program for elementary and middle school students and the general public that has been running since 2022. We plan to share our experiences of and lessons from the problems encountered when developing and operating. Participants will have the opportunity to explore appropriate topics and methods of STEM education programs that start from the context of their own local community and connect to global STEM issues.

LOCATION: TR701

13:30-16:30 Session PCW4: Ticketed Workshop

Pre-conference Workshop by Stick'Em, Singapore [Ticketed]

Hands-on Workshop with STEAM Kit

At Stick 'Em, our mission is to make quality STEAM education accessible to ALL. Besides an affordable STEAM Kit to build things with, our online platform provides children with super fun activities and challenges. Put together, our STEAM ecosystem teaches them scientific concepts while developing their soft skills such as creativity, critical thinking, problem solving

and more. With this kind of holistic approach, our aim is to guide their growth into becoming problem solvers for our future.

Stick ‘Em is currently active in 7 countries across SEA with thousands of students in partnership with various schools and organisations. We will expand globally with a consumer oriented product in 2025 to make a significant dent to the 1B over children who don’t have access to STEAM education right now.

During this 3 hour workshop, participants will have hands-on experience with block coding to program a robot to perform various tasks to solve authentic problems related to the theme of environmental sustainability. This curriculum that is designed for K-12 students will illuminate how problem/solution/user centric approaches can be seamlessly incorporated into the STEM curriculum anywhere.

LOCATION: TR702

13:30-16:30 Session PCW5: Ticketed Workshop

Pre-conference Workshop by Timothy T. M. Tan and Yong Sim Ng [Ticketed]

Incorporating Physical Computing Devices and Simple Coding into STEM Learning Activities

Digital literacy is a core competency in the current global landscape driven by technological advances. STEM curricula with a focus on harnessing technological solutions for authentic problem-solving affords students opportunities to grow their digital competencies. Physical computing devices such as the BBC micro:bit and the MakeBlock HaloCode are pedagogically-oriented technological tools that teachers can include in integrated STEM lessons to imbue such skills and mindsets of change. In this workshop, the participants will have hands-on experience with these devices and their easy-to-learn visual coding interface. Examples of integrated STEM curriculum materials that involve these devices in authentic problem-solving will be shared. This workshop is suitable for participants with little to no knowledge of coding but have an interest in technology-infused STEM curriculum activities.

LOCATION: 7A-01-01

PROGRAM FOR THURSDAY, JUNE 27TH

08:00-09:00 Registration

NOTE: For all queries and help, the Secretariat is located in TR714 (Block 7, ground floor)

LOCATION: Outside LT1

09:00-10:00 Welcome Ceremony

LOCATION: LT1

10:00-11:30 Keynote 1: Gillian Roehrig

Gender Equity Related to Integrated STEM in K-12 Classrooms

Recent educational reforms in the United States promote integrated science, technology, engineering, and mathematics (STEM) as a means of remaining globally competitive and advancing the knowledge and thinking skills of all students (National Research Council, 2012). However, despite efforts to improve access and quality of STEM education, women continue to be underrepresented in STEM fields (National Science Foundation, 2017). Given the prevalence of small group activities in K-12 STEM instruction, it is important to understand how students engage in epistemic discourse as they develop design solutions to real-world problems and engage in authentic STEM practices, parallel to those of STEM professionals. Given issues with gender equity in STEM, it is particularly important to consider the engagement of girls in STEM discourse and the impact on their developing STEM identities.

LOCATION: LT1

11:30-12:30 Lunch

12:30-14:00 Session 1A

STEM curriculum and teaching

CHAIR:
Fan Liu

LOCATION: 7A-01-07

12:30 *Koh Chee Kiang* and *Pang Jeng Heng*

Nurturing 21st CC through Physics IBL and STEM Activities

ABSTRACT. Nurturing 21st CC in students is a current focus to prepare them for a future where continual learning is needed to thrive in a fast changing and technology-driven world. Students in our school learn Physics through investigative-driven and inquiry-based hands-on STEM activities that focus on real-world applications of the scientific approach in problem solving. We designed formal and informal programme to help develop our students in areas of critical, adaptive, and inventive thinking and communication, collaboration, and information skills. Modelling our inquiry-based lessons after the 5E Learning Cycle, (Bybee, 2006), we designed activities where

students work cooperatively in groups, and then present and discuss their solutions using the whiteboarding process with their teacher and peers. Whiteboarding promotes active learning among students by engaging them in the learning process through reading, writing, discussion, analysis, synthesis and evaluation. (Smart Technologies inc, 2006). Whiteboarding is a valuable teaching tool because it facilitates the declaration of understanding (Weller, 2016, p21). By making each group's investigation public has also helped to ensure the members of each group are able to explain their ideas explicitly to others. In this study which spans 2017 to 2023, we used both quantitative (questionnaire) and qualitative (focus group interview) feedback to evaluate the impact of our inquiry-based STEM activities and the application of whiteboarding on students' joy in learning. When compared with our conventional teaching approach, our findings in this study suggested that our students felt more joy in learning, were more confident in forming and communicating explanations through meaning-making, were better engaged and had a keener interest and motivation towards learning. We collected feedback from students in 2023 and we noted quite similar observations albeit some improvements. In this process we noted that our students acquired attributes of an engaged learner and demonstrated beginning inclinations of a life-long learner. We also found students in the Intervention group performed better in conceptual understanding in Physics as seen in their better results for all the Quiz questions to varying degree compared to Control group, with significant difference between the performance of the 2 groups in some questions in our T-test analysis.

13:00 *Uki Rahmawati*, *Wisnuningtyas Wirani*, *Russasmita Sri Padmi* and *Sharon Locke*

The Affordance of STEM Activity to Foster Computational Thinking Skills in Junior High School Mathematics Classroom

ABSTRACT. An integrated STEM Activity is defined as a learning experience that allows the students to apply mathematics and science knowledge and skills, using the Engineering Design Process and assisted by technology, to solve real-world problems. An integrated STEM activity helps develop skills deemed important for students to thrive as 21st-century citizens and workforce, including computational thinking (CT) skills, which are important skills for a technology-based society. Given this importance, additional research is needed on what CT skills can be supported through integrated STEM activity, and how. Two integrated STEM activities for mathematics classrooms were implemented in two grade 7 classes in Yogyakarta, Indonesia. Each classroom contained 32 students with mixed backgrounds and abilities. Videos of students in the classroom and students' worksheets were analyzed qualitatively by identifying and describing vignettes of the classroom interaction that could be categorized as one of the computational thinking skills. The findings suggest that integrated STEM activities designed for mathematics classrooms can foster abstraction skills (data collection and analysis, pattern recognition, and modelling) and debugging, by embedding inquiry-based activity in the Imagine phase of the engineering design process.

13:30 *Jing Lei* and *Fan Liu*

Project-based learning for Engineering Design in a Chinese Primary School: The Evolution of Curriculum Development Principles Through Three Projects

ABSTRACT. Goals and Significance China's 2022 compulsory education science curriculum standard has included a distinctively hands-on module "engineering design and materialization". However, due to limited time and lack of experience, teachers struggle to effectively infuse high-quality engineering design projects into science class. The goal of this paper is to delineate and analyze a Chinese primary science

teacher's journey of exploring project-based learning in engineering design and the development of a curriculum model which suits the Chinese school science context. Methodology This paper adopts a case study method, collecting course material, interview data, video recordings, students' products, and assessment data to delineate the evolution of a set of curriculum development principles through three projects and the professional growth of the teacher for and with the students. Findings and Discussions: Engineering design projects can be effectively done in four sessions within the Chinese school science context, with the first session devoted to analyzing and breaking down the problem, the second to designing solutions, the third to prototyping and testing, and the fourth to presentation, feedback, and improvement. For students, they feel ignited in collaboratively solving a real-life problem instead of just completing a task externally given and controlled by the teacher. They apply what they've learned and seek information on whatever to be learned, and they ask for help from all sources available. They enjoy the process and feel a deep connection with their products. For teachers, through learning by doing, they get more confident in project-based teaching, and their previous beliefs about teaching and students are challenged. Implications of findings: The concept of project-based learning is not foreign to Chinese teachers, but how to create a project which originates from real life situation and is both age-appropriate and intellectually challenging to pupils, is not a easy task. Teachers need to have faith in pupils to unleash their potential. And teachers should use their professional discretion to reallocate time within school science subject in order to ensure the time frame needed by engineering design.

12:30-14:00 Session 1B

STEM curriculum evaluation, and assessment

CHAIR:
Dr. Anthony Joseph
LOCATION: TR701

12:30 *Kittisak Manopattanakron*, *Panya Jangsawang*, *Suriya Khunwandee*, *Kittipot Konsanthia* and *Chatree Faikhamta*

Teachers' understanding of integrating formative assessments into STEM lessons
PRESENTER: *Panya Jangsawang*

ABSTRACT. Teachers' understanding of formative assessment is one of the key elements of STEM learning and its implementation in classroom practices. However, little is known about how teachers understand and use formative assessment in STEM activities. This study aimed to examine how teachers understand formative assessment and how they combine formative assessment with STEM activities to improve students learning. Eliciting, Interpreting, and Responding (EIR), one of the formative assessment models, was introduced to 15 science teachers during their professional development program. Teachers' understanding and their lesson design for formative assessment were captured by means of group discussion and their STEM lesson plans. The data were analyzed by an inductive process. The results indicated that science teachers had developed their own key characteristics of formative assessment and could integrate the EIR formative assessment model into each step of the engineering design process. They become aware that intended learning outcomes should be alongside EIR. They have also learned that considering students' STEM competency helps them easily track students learning and promote their learning progression. They could indicate pedagogical techniques to elicit students' STEM learning while interpreting the

students' ideas and providing feedback to learners, which are very challenging. In this study, we also highlight the role of teachers' reflection-in-action and reflection-on-action in their formative assessment practices in the STEM classroom.

13:00 *Tri Wahyuni*, *Hendra Tan*, *Yunika Nugraheni* and *Laudya Sakti*

Assessment of Problem-solving Skills in STEM Learning with Design Thinking Approach

ABSTRACT. STEM-based learning is considered as an effective way to develop 21st-century abilities, particularly problem-solving skills. Design Thinking, a method focused on problem identification and solution generation, is increasingly applied to support the development of problem-solving abilities in students. This study focuses on developing comprehensive assessment of problem-solving skills by evaluating proposal assessment objects, implementation processes, presentation of project results, and reflection. Assessment is conducted based on a rubric that reflects indicators of problem-solving skills, namely: 1) problem identification; 2) action planning; 3) execution; and 4) evaluation. The research subjects involve 7th grade students in an SMP during the 2023/2024 academic year. Data Collection methods employ observation, interviews, and analysis of student reflection results. The findings of the study highlight the correlation between proposals, implementation processes, presentation of project results, and reflection with demonstration of problem-solving skills. Furthermore, the researchers discovered that, in addition to the primary focus of the study, other 21st-century skills – such as Critical Thinking and Creativity - can also be assessed through a STEM-based learning framework.

13:30 *Dr. Anthony Joseph* and *Dr. Claude Turner*

An Investigative Analysis of STEM Subjects Inclusion and Outcomes in the English Speaking Caribbean Nations and the United Kingdom Secondary Education System

ABSTRACT. This study investigates and evaluates and assesses the similarities and differences of the English speaking Caribbean (ESC) nations and the United Kingdom's (UK's) secondary education systems through the Science, Technology, Engineering, and Mathematics (STEM) examination subjects administered to 11 graders and those subjects' implications for national development and personal growth. As the UK is a developed nation and the ESC are comprised of developing nations, the UK is used as the reference country to judge the level of progress that ESC nations have made or need to make to achieve developed national statuses. Therefore, this work is significant as it can serve to bring awareness to ESC nations' leaders and policy makers on what is needed to advance their STEM educational infrastructure for K-11 graders.

Sources of data and information for this study include STEM subjects offered and their syllabi descriptions in both the ESC and UK secondary education systems, 2018 and 2022 Program for International Student Assessment (PISA) surveys, and the Caribbean Secondary Education Certificate (CSEC) and the UK's General Certificate of Secondary Education (GCSE) examinations statistics for 2019 - 2023. Initial findings show that for both the CSEC and GCSE English language and mathematics are core subjects and while science is emphasized in both systems, it is a core subject for the GCSE. Moreover, while information technology is offered for the CSEC, for the GCSE the more general computer science and engineering are offered. Additionally, in both systems, mathematics is relatively challenging for students. Overall, ESC's CSEC subjects should include computer science and engineering and both systems need to

develop and implement strategies to improve students' mathematics performance. Students appear to do well in the physical sciences in both systems. However, deficiency in mathematics is likely to hamper graduating students' successful pursuit of mathematics-intensive post-secondary STEM education and careers in such fields as engineering, computer science, data science, and quantum computing.

12:30-14:00 Session 1C

STEM learners and learning

CHAIR:
Sunanthicha Ngamsong

LOCATION: TR702

12:30 *Chien-Liang Lin*

Exploring the Relationship between Undergraduates' Cognition, Skill and Emotion in STEAM Learning

ABSTRACT. One of College General Education goals is to cultivate students' creative application and interdisciplinary ability with humanities, social science and natural science three categories' courses. As Science, Technology, Engineering, Art and Mathematics (STEAM) education been using in high education, some competences like knowledge integration and project skill were emphasized. STEAM integrated education supports the challenges for cooperative problem solving, especially face the climate changes, COVID-19 and sustainability global issues. The theory of planned behavior (TPB) was employed as a theory model to investigate the factors influencing students' STEAM learning behaviors. The purpose of this study was to explore how students' cognition, skill and emotion factors affect their STEAM learning with TPB. An online self-report instrument had designed as 28 items included knowledge integration, project skill, attitude, self-efficacy, subjective norms and intention six constructs. To ensure construct validity, we collected three expert instructors' comments to adjust this instrument. Total 2231 effective responses (1162 female, 1069 male) who enrolled in 162 different general education courses at one central Taiwan university. In order to confirm the reliability of this scale, total Cronbach alpha reliability coefficient was .96 and each construct ranged between .73 and .91. Structural equation modeling revealed that data had an acceptable model fit (Standardized RMR = .0423, RMSEA (root mean square error of approximation) = 0.065, CFI (comparative fit index) = 0.941, TLI (Tucker- Lewis index) = 0.946). The results show that students' attitude, self-efficacy and subjective norms toward STEAM enhance creating interdisciplinary artifacts. This study highlights the importance of knowledge integration and project skill which affect the self-efficacy, attitude toward students' STEAM artifacts.

13:00 *Sunanthicha Ngamsong*, *Narissara Suaklay* and *Luecha Ladachart*

Thai Students' STEM Identity with Regard to Educational Level and Gender

ABSTRACT. As the global workforce becomes increasingly required to be literate in STEM, students must strongly identify with STEM. Research, however, indicates that students' identification with STEM tends to decrease as they move toward higher grades. This tendency is most likely to occur among girls, who are typically marginalized within STEM education. Given the lack of research on students' STEM identities in Thailand, we investigated the extent to which students in elementary and secondary education identify with STEM and whether such identifications are related to gender. Participants included 174 boys and 109 girls in three schools in northern

Thailand. Of these participants, 157 were in the elementary grades and 126 in the secondary grades. They completed a Likert-type questionnaire, which was validated and utilized in the country. It consisted of 10 items measuring interest, performance, and recognition in STEM in a five-point scale. Its reliability was acceptable, with a Cronbach's alpha of 0.840. Student responses were analyzed by calculating the means and subsequently comparing them using Mann-Whitney U tests with regard to educational level and gender. The results revealed that, on average, secondary graders demonstrated STEM identity more strongly than elementary graders in all three aspects. However, only interest ($U = 7309.000$, $p < .001$) and performance ($U = 7730.500$, $p < .001$) were significant. Girls showed STEM identity more strongly than boys in all three aspects. However, only interest ($U = 7865.500$, $p = .007$) was significant. As these results contradict the literature, they are discussed from a sociocultural perspective.

12:30-14:00 Session 1D

STEM teacher and teacher education

CHAIR:
Chalongwoot Janhom
LOCATION: TR703

12:30 *Kevin Manunure* and *Allen Y L Leung*

Integrating Inquiry and Modeling When Teaching Density in Lower Secondary School: an iSTEM Approach

ABSTRACT. The world has been increasingly shaped by Science, Technology, Engineering and Mathematics (STEM). This has resulted in educational systems across the globe implementing STEM education. To reap maximum benefits, researchers are now advocating for the integration of STEM domains, citing many benefits associated with it. In recent studies, the integration of science and mathematics has become increasingly popular. The domains are much more suitable for integration because of their fields of application and their mutual approach towards problem-solving. However, there is little empirical evidence to drive the development of a practical model for classroom implementation. This study aims to develop an integration model through integrating mathematics and science concepts when teaching the concept of density to two classes of Form 1 (13-14 years) students. A mathematics and a science teacher went through two cycles of lesson study, integrating and teaching the concept of density. The lesson series were carried out in a science laboratory at a secondary school in Zimbabwe. Processes of mathematical modeling and the BSCS 5E Instructional Model of inquiry were used as basis for categories to analyze how the teachers realized or intended to implement the integration of mathematics and science. From the study, the dimensions of an emerging pedagogical integrative model pertaining to the science teacher and to the mathematics teacher were drawn and compared. The model show striking commonalities in the processes and sequences of inquiry and modeling, and they also appear to be influenced by the teacher's characteristics. Further, the model were compared against those that have been previously developed and the findings of earlier studies on the topic. The study highlights and provides empirical evidence for the feasibility of integrating mathematics and science in a normal classroom situation. The integrative model can be used in the analysis of interdisciplinary teaching sequences that aims to promote integration of inquiry-based learning and mathematical modeling in education.

13:00 *Pattranan Vaidyakula*, *Sasithep Pitiporntapin* and *Wendy Nielsen*

Pre-service Teacher Perspectives on Developing their own STEM Teaching Competency

ABSTRACT. STEM teaching competency involves a blend of knowledge, skills, and abilities enabling educators to proficiently teach Science, Technology, Engineering, and Mathematics (STEM), fostering critical thinking, problem-solving, and cultivating an interest in STEM fields. STEM teaching competency encompasses an understanding of STEM education, including the construction and execution of STEM lessons and the creation of appropriate assessments. To improve the STEM teaching competency of preservice teachers (PSTs), this research pursued three main objectives: 1) to conduct a needs identification for STEM teaching competency, 2) to analyze the identified needs that focus on the development of PSTs' STEM teaching competency, and 3) to propose a solution to address the identified needs and enhance PST STEM teaching competency. The study involved 16 PSTs selected purposefully from those who had taken STEM courses. Research instruments included a needs assessment questionnaire and a semi-structured interview protocol. Quantitative data from the questionnaire were analyzed using mean, Standard Deviation (SD), and the modified priority needs index (PNImodified), while qualitative data from interviews were subjected to content analysis. Questionnaire data revealed areas of concern for PSTs regarding their STEM teaching competencies. The primary areas they highlighted were creating scenarios for design challenges and developing lesson plans, which they identified as crucial needs for enhancing their STEM teaching competency (PNImodified=0.62). The interview focus was on understanding both their perceived needs and the reasons behind them. PSTs recognized difficulties in choosing topics for STEM problem scenarios and a lack of skill in developing STEM lesson plans. PST also suggested solutions including a recommendation for more dedicated time in the pre-service program for developing STEM lesson plans. Additionally, they also recommended incorporating more reflection activities on STEM problems in order to better align the problems with STEM learning activities and then, more explicit opportunities for practicing the teaching of these lessons.

13:30 *Chalongwoot Janhom*, *Ekkapong Benjakul*, *Tharuesean Prasoplarb* and *Chatree Faikhamta*

Revealing Co-Teaching to Interrogate High School Students' STEM Practices throughout STEM Career Experiences

ABSTRACT. STEM practices reveal the activities around a scientist inquiring about knowledge and an engineer designing solutions. Meanwhile, the scholars develop STEM lessons by emphasizing the scientific contents or concepts or the client's needs, but a few literatures shared that STEM teaching practice requires more understanding of teaching procedural knowledge and the nature of each practice. Also, to accomplish a STEM lesson with worldwide views, real-world problems, or the know-how of multiple solutions from STEM careers that might be too complex to design by oneself. This study aims to interrogate the teaching of STEM practices for 30 high school science stream students and how they change over five STEM learning activities based on various STEM careers. A qualitative descriptive case study was conducted in this study; the transcriptions of co-teaching members before, during, and after teaching were collected and analyzed by deductive coding, and the students' tasks were gathered to confirm their changes and the effectiveness of teaching practices. The findings presented the three STEM practices had shifted to the highest level which consists of

planning or carrying out the solutions, using or developing the models, and using mathematical or computational thinking to optimize the solutions. The gathering of combined STEM careers in probing questions during finding out and developing solutions led them to connect necessary factors with optimizations, while a mathematician's view around statistics, probabilities, or linear programming further engaged them in risk-taking and decision-making on the solutions based on scientific ideas. In contrast, this co-teaching aimed to improve students' critiquing practice through entrepreneurial role-playing, but we found out students lacked understanding and capacity to use or engage evidence. That affected all activities that require the quality of evidence in explaining, communicating, and arguing as the difficulty of learning procedural knowledge, while explicit sharing STEM career goals in each task would guide them to reach or choose the appropriate evidence. However, this study provides the framework of S.E.M. co-teaching with combined indicators based on STEM careers to reimagine designing the next normal of STEM lessons for science teachers or STEM teachers and connect STEM lessons to authentic contexts.

12:30-14:00 Session 1E

STEM teacher and teacher education

CHAIR:
Melanie Nash

LOCATION: TR704

12:30 *Pattamaporn Pimthong*, *Sutasinee Kityakarn*, *Tassaneewon Lertcharoenrit*, *Songchai Ugsonkid* and *Ratiporn Munprom*

A STEM Partnership into Practice: Creating a Checklist for STEM Partnerships

ABSTRACT. STEM education has gained popularity at all levels of education in recent decades. However, integrating teaching across different disciplines remains a challenge. The importance of STEM professional learning is increasingly focused on integrated STEM. We found that most teachers faced difficulties working collaboratively with other teachers from different disciplines. Additionally, teachers faced challenges working with STEM people outside of schools, such as engineers, parents, and experts in STEM disciplines. This study presents the development of a STEM partnership guideline as a checklist. We developed this checklist while working together in our STEM partnership and as mentors of STEM partnership professional development programs. We, as researchers, work collaboratively in STEM partnership. Our STEM partnership consisted of five researchers: a science educator, a mathematics educator, a scientist, an engineer, and a science teacher. Our theoretical framework is rooted in integrated STEM and constructivism learning theory. The checklist provides teachers with guidelines for creating their STEM partnership. This paper presents how we developed the checklist and the trials with teachers. The checklist has four themes: 1) Eliciting and equipping all parties with an understanding of STEM, 2) Creating STEM lesson plans, 3) STEM team teaching, and 4) Reflecting on team teaching. These themes emerged from our previous research on developing the STEM partnership. We identified the items on the checklist within each theme to help STEM teachers prepare for a STEM partnership. The checklist was trialed with ten STEM teachers and revealed suggestions for redesigning it to help teachers create their STEM partnerships.

13:00 *Mustakeem Awae*, *Chatree Faikhamta* and *Jeerawan Ketsing*

Science Teachers' Pedagogical Reasoning for Teaching STEM.

ABSTRACT. Pedagogical reasoning, as one of the major components of the teacher knowledge base, is crucially important in teacher education. While many studies have explored STEM teaching, little emphasis has been placed on the dynamic decision-making processes of teachers. This paper reports on an exploratory study that investigated the pedagogical reasoning for teaching STEM of three high school science teachers as they gained experience in teaching STEM at the upper secondary level. STEM pedagogical reasoning (STEM-PR) is developed in the real context of a teacher's practice; hence, teachers need to have the experience of learning to teach with STEM in their actual classes. We found that the anxiety regarding the scientific content of teachers, the level of understanding in implementing STEM curricula, as well as the underlying differences in integrated STEM thinking, significantly influence teachers' STEM-PR and instructional design. The results indicated three distinct cases of integration among the participants. Interviews with teachers from each case revealed three themes that varied across teachers' experiences: the nature of integration and choosing between STEM disciplines. Further, it appears that the degree of STEM integration that occurs in instruction may be related to teachers' ability and teacher learning. Theoretical and practical implications are discussed for how pedagogical reasoning can be integrated into learning design curricula and also shed light on the importance of teacher-educators modelling both types of PCK, as both are equally important for in-service teachers.

13:30 *Melanie Nash*, *Ange Fitzgerald* and *Ondine Bradbury*

Understanding pre-service teachers' perceptions of STEM education through immersive experiences

ABSTRACT. Primary school teachers significantly influence students' perceptions, attitudes, and aptitude for STEM subjects, making their STEM understanding and enthusiasm pivotal for the next generation's engagement in these crucial fields. To address this, we present a pioneering project to empower primary pre-service teachers with immersive experiences to deepen their connection with STEM concepts and teaching methodologies. This project immerses 28 primary pre-service teachers in hands-on STEM labs, school-based pedagogical experiences, and real-world applications of STEM education. This immersive course is delivered as part of a Master-level initial teacher education program, encompassing five intensive one-day workshops over September and October. Data collection, ongoing throughout the course, will conclude in early November. Participants in this study are 'career changers' from diverse professional backgrounds. Our study leverages two key data sources, pre- and post-survey data and focus group discussions. We anticipate that the outcomes of this project will not only enhance primary pre-service teachers' STEM knowledge but also empower them to advocate passionately for STEM education in their future classrooms. By bridging the gap between pre-service educators' perceptions and the transformative potential of STEM, this project seeks to cultivate a new generation of STEM teachers capable of inspiring and engaging students in an ever-evolving STEM-driven world. Early results indicated changes in the participants' perceptions about STEM in the classroom and also highlighted the unique perspectives and skills that career changers brought to STEM learning and teaching. Ultimately, this study assists in advancing teacher preparation and enhancing the quality of STEM education in schools. It equips future educators with invaluable tools to excel in resource-constrained, time-sensitive educational environments, promising a more promising future for STEM education.

12:30-14:00 Session 1F: Symposium

Symposium

LOCATION: 7A-01-06

12:30 *Jessica Seah Mei Ying*, *Joyce Ng Hwee Koon* and *Rishvinder Singh*

Igniting minds and S.O.A.R.ING High

ABSTRACT. Our Applied Learning Programme (ALP) focuses on developing problem-solving skills and nurturing innovation through the integration of concepts involving Science, Technology, Engineering and Mathematics (STEM). With a burgeoning aviation industry in Singapore, our school has focused our ALP on aerospace. With this, our students will be able to tap on exciting prospects in the aviation sector or other STEM-related fields.

In addition, the programme seeks to underscore the relevance of students' learning to the STEM industry, allow students to apply STEM knowledge to solve real-world issues, and to facilitate students' exploration of post-secondary educational and career opportunities.

During the presentation, participants will learn about the three tiers of our ALP, namely our ALP lessons, workshops and competitions, student development in our Singapore Youth Flying Club co-curricular activity (CCA), teacher professional development, and overseas exchange programme. Participants will also hear about our efforts to engage students through innovation and to empower them by amplifying and harnessing their interests in Science, Technology, Engineering and Mathematics. We continuously adapt and review our programmes during PLT sessions to improve the learning experience for our students based on present demand for STEM skills.

We carefully planned our CCA programme to ensure students not only learn the various skill in aviation but also hone leadership skill and other 21st century CC skills.

With the strong partnership with CAAS, Science Centre, Rolls Royce and various Institutes of Higher Learning, we aim to uphold partnerships within the industry and provide our students with a diverse range of hands-on learning experiences through our STEM ALP Day. Likewise, our continuous exchange program with Toulouse Lycée-Saint Exupery has provided opportunities for our students and teachers to engage in cultural activities and experiences related to aviation.

In terms of professional growth, ALP teachers alternate between immersive learning journeys, immersion programs, and seminars to gain firsthand insights and stay abreast of the latest developments in the aviation industry. Our annual training sessions, conducted by various vendors, ensure we acquire authentic and pertinent knowledge, like drone coding and Flight Simulator operation.

12:30-14:00 Session 1G: Workshop by Texas Instruments

Workshop: Exploring Robotics with Texas Instruments Innovator Technology

Presenter: Mr Eric Chin

Synopsis:

Exploring STEM experiences in developing students' abilities to collaborate, think imaginatively and problem-solving skills by using TI-Innovator Rover. Among the hands-on activities, the presenter will use the Python code to program the TI-Innovator Rover. At the end of the workshop, you may get some ideas how TI-Innovator Rover can bring excitement and critical thinking to your math and science class in secondary school.

LOCATION: TR705

12:30-14:00 Session 1H: Workshop by VEX Robotics

Workshop: Igniting Young Minds: A Project-Based Learning Approach promoting Design Thinking with Robotics

Presenter: Andy Lee

Synopsis:

This interactive workshop equips educators with a project-based learning (PBL) approach that integrates Robotics and design thinking.

In this session, you will:

- Explore the foundations of VEX robotics, gaining a hands-on understanding of the platform and its capabilities.
- Discover how to weave computational thinking principles into VEX activities, empowering students to code, sequence, and troubleshoot effectively.
- Delve into the design thinking framework and its application in robotics projects.
- Engage in a collaborative activity, applying design thinking to tackle a complex problem and build a VEX robot solution.
- Leave with a comprehensive toolkit including project ideas, curriculum resources, and strategies to implement this approach in your classroom.

This workshop is ideal for educators who:

- Want to introduce or enhance their use of Robotics in the classroom.
- Seek to integrate computational thinking and design thinking into STEM lessons.
- Desire to foster a project-based learning environment that encourages collaboration and problem-solving.

Participants will gain:

- Practical knowledge of VEX robotics and its educational applications.
- Effective strategies to integrate computational thinking into VEX activities.
- A step-by-step approach to implementing design thinking in project-based learning.
- Ready-to-use resources for immediate classroom implementation.

Get ready to transform your classroom into a hub of innovation and empower your students to become the next generation of STEM leaders!

LOCATION: TR706

14:00-14:30 Tea Break

14:30-16:00 Session 2A

STEM curriculum and teaching

CHAIR:
Shotaro Naganuma

LOCATION: 7A-01-07

14:30 *Christina E. M. Hutabarat*, *Uncok Manigor Jokkas Siahaan* and *Ruth Marlina Hutabarat*

The implementation and integration of Kurikulum Merdeka and STEM at all levels of education in Indonesia.

ABSTRACT. Indonesia's new educational curriculum, Kurikulum Merdeka, has successfully integrated the Independent Curriculum and STEM education. The primary objective of this integration is to enhance the learning experience for students at the elementary, junior high, and high school levels by providing them with better facilities and developing the competencies of both teachers and students. The STEM-based curriculum utilizes project-based learning to make education more relevant and contextual, with teachers acting as facilitators. To determine the effectiveness of this curriculum and its integration with STEM in classrooms, an analysis is required. This study aims to identify the barriers and challenges faced by teachers in implementing Kurikulum Merdeka and STEM, the consequences of this integration, and the readiness of teachers to apply models or approaches to organize it. To gather data for this study, open-ended and close-ended questionnaires will be distributed to teachers in North Sumatra, West Java, and DKI Jakarta.

15:00 *Purna Subba* and *Chenga Dorji*

Exploring Generative AI Tools in STEM Education at Higher Learning Institutes: Global Perspectives.

ABSTRACT. This study investigates the global application of generative AI Tools in STEM Education at Higher Learning Institutes, aiming to enlighten Bhutanese scholars. Embracing AI in education aligns with modern demands, yet ethical concerns arise, such as students using AI like ChatGPT for academic dishonesty. Strategies

proposed by experts suggest using AI as an assignment aid and creating policies to curb cheating, marking a pivotal shift in education.

The objectives include exploring AI's potential in enhancing STEM education, teacher perspectives on AI integration, educator interest, and challenges in implementing AI tools in STEM education.

Through systematic research involving surveying academic databases and thematic analyses, 30 relevant papers were scrutinized. The study identified key themes, regional differences, and reliable findings, offering a comprehensive understanding.

Key findings highlight AI's potential to improve personalized learning, analytics, and automation in STEM education but raise concerns about shifting teacher roles and decision transparency. Despite widespread educator interest, obstacles persist in integrating AI into education. AI elements enhance career readiness, detect plagiarism, reveal diverse student perceptions, and emphasize the need for AI literacy education.

The research emphasizes the transformative impact of AI in STEM education and broader societal contexts, calling for multidisciplinary collaboration to navigate its complexities effectively. While highlighting AI's promise, it stresses the importance of addressing challenges, ethical concerns, and academic integrity.

For Bhutanese educators, the study recommends responsible use of AI for quality learning experiences advocating leveraging AI tools effectively and explores diverse global perspectives while acknowledging potential pitfalls. Ultimately, the research underscores the transformative potential of AI in STEM education, urging collaborative efforts and ethical considerations for its responsible integration.

15:30 *Shotaro Naganuma*, *Kosaku Kawasaki* and *Naoya Sakuma*

Development of a STEM Learning and Teaching Theory GPT

ABSTRACT. Knowledge mobilization—efforts to understand and strengthen the relationship between research and practice—is increasingly being recognized in the field of education. However, barriers such as perceived inaccessibility and lack of time and skills can be significantly challenging for practitioners (e.g., teachers). To address this challenge, we employed generative Artificial Intelligence (AI) to develop the "STEM Learning and Teaching Theory Generative Pre-trained Transformer (GPT)," which could act as a research broker. This GPT possesses research knowledge on STEM education research findings. It is designed to elucidate the difficulties of learning these concepts and highlight teaching methodologies deemed particularly effective for facilitating comprehension among learners. In our study, we had science and mathematics education experts evaluate the performance of the developed GPT. We input several notoriously difficult science or mathematics concepts for middle school students into the GPT (e.g., Ohm's law, state changes, irrational numbers, and proof). Experts (educators and researchers) independently evaluated the outputs of the GPT on plausibility (how convincing the explanations were) and utility (how useful the explanations were in science or mathematics lessons). The results indicated that the developed STEM Learning and Teaching Theory GPT could outperform GPT3.5 or GPT4.0 across various concepts in science and mathematics, but its outputs were still unstable. This study leverages the potential for utilizing generative AI to enhance STEM education. Future studies should refine the quality of information and instruction

input into our GPT model to produce more plausible, useful, and stable outputs for other STEM concepts applicable to daily teaching practices.

14:30-16:00 Session 2B

STEM learners and learning & Sociocultural issues in STEM Education

CHAIR:
Jina Chang

LOCATION: TR701

14:30 *Daiki Nakamura*, *Kodai Miura*, *Soichiro Kudo*, *Mikiharu Ishitobi* and *Shotaro Naganuma*

Developing a Diverse Interests Scale for STEM Learners: Based on the ROSES Survey in Japan

ABSTRACT. Increasing learner interest in STEM is a key challenge in STEM education. Historically, the measurement of interest in STEM fields has used abstract items at the domain level and lacked specific items at the topic level. An interest scale with more diverse and topic-specific items is required to comprehensively measure the diverse interests of STEM learners. Therefore, this study aims to develop a diverse interest scale for STEM learners (the DI-STEM scale). We analyzed data from the Relevance of Science Education – Second (ROSES) survey, which involved 3,417 Japanese 9th-grade students, identified diverse interest areas, elucidated the factor structure of these interests, and evaluated item properties to construct a reliable, topic-level interest scale. The DI-STEM scale encompasses 50 items representing various difficulty levels and content areas and demonstrates robust statistical properties, including high discrimination and gender equity. The findings highlight the scale's potential to enhance personalized STEM learning by identifying individual and collective student interests, thereby informing the design of more engaging and effective STEM education programs. Future research directions include validating the DI-STEM scale across different cultural contexts and integrating it with adaptive learning technologies to personalize STEM education further.

15:00 *Songpon Wongpeng*, *Narissara Suaklay* and *Luecha Ladachart*

Gender Differences in Thai Elementary Students' Creative Confidence

ABSTRACT. As policies promoting STEM education to increase economic growth spread globally, students must be prepared to develop valuable innovations, which require not only creativity but also creative confidence. Despite the existence of research focusing on gender differences in students' creativity, studies examining differences between boys' and girls' creative confidence remain scarce, with mixed results being reported. Aiming to better understand this issue, we explored the creative confidence of fourth to sixth graders. Participants, who included 26 boys and 27 girls in two schools in northern Thailand, completed a Likert-type questionnaire, which was validated and utilized in the country. It consisted of eight items asking the students to self-report their perceptions of creative confidence, ranging from most (5) to least (1), in various situations. Its reliability was acceptable, with a Cronbach's alpha of 0.701. Student responses by gender were analyzed by calculating the means and comparing them using an independent sample t-test. The results revealed that, on average, boys and girls did not significantly differ in terms of creative confidence ($t(51) = 1.605$, $p = .057$). However, when we focused on individual items, Mann-Whitney U tests showed that boys were more confident than girls in their creativity when making

models (U = 511.000, p = .002) and solving complex problems (U = 467.000, p = .013). In contrast, girls were more confident than boys when creatively solving problems (U = 242.000, p = .018). These results suggested that gender differences in students' creative confidence may manifest depending on the situation.

15:30 *Jina Chang*, *Tang Wee Teo* and *Aik Ling Tan*

The features of epistemic norms formed in integrated STEM problem-solving: A study of secondary students' STEM lessons in Singapore

ABSTRACT. Problem solving in integrated science, technology, engineering, and mathematics (STEM) practices is not straightforward because it entails dynamic processes from the complexity and diversity of real-world STEM problems. To explore practical ways to support students' STEM problem solving, this study focuses on the perspective of norms as 'shared behaviour patterns desirable in a community' by investigating the features and impact of epistemic norms formed in STEM problem-solving. Data consisted of lesson observations, interviews, students' artefacts, teachers' notes, and group chats from secondary students' STEM lessons in Singapore. These students participated in a three-year programme to build their STEM capital. This paper focuses on the first-year programme that included a STEM hackathon, 3-day learning journey, and 10-weeks of STEM inquiry. Norms were extracted based on three essential criteria namely justifiability, sharing, and behaviours (Chang & Song, 2016). Results showed three central norms with six different attributes being found in the phases of STEM problem-solving. Among the six attributes, three attributes as being useful, creative, and iterative reflected STEM-oriented values; however, another three attributes as accessible, concrete, and feasible were shown as the contextual features of implementing STEM practices. Based on these results, educational implications are discussed in terms of understanding and supporting students' STEM problem-solving.

14:30-16:00 Session 2C

STEM learners and learning

CHAIR:
Jennifer Long Miaw Ying
LOCATION: 7A-01-06

14:30 *Jarupa Kitcharoenpanya* and *Pongprapan Pongsophon*

Shaping Innovators: How Gender, Creative Thinking, and STEM Proficiency Influence Design Self-Efficacy in Students

ABSTRACT. This study embarks on an exploration of the factors influencing students' self-efficacy in design process practices, with a specific focus on the roles of gender, creative thinking, and academic achievements in science, technology, and mathematics. Design process practices, which encompass a range of skills from problem identification to solution prototyping, are increasingly crucial in our technologically driven world. They enable students to apply theoretical knowledge in practical, innovative ways, bridging the gap between academic concepts and real-world applications. The primary aim of this research was to determine the extent to which these aforementioned factors predict and enhance students' self-efficacy in engaging with such design processes. To this end, data were collected through detailed questionnaires from a representative sample of 200 students across three schools in the Bangkok metropolitan area. The research methodology incorporated a blend of descriptive statistics, correlation analysis, and multiple regression analysis. This

approach was designed to provide a comprehensive understanding of the interplay between gender, creative thinking, science, technology, and mathematics achievements, and their collective impact on self-efficacy in design process practices. The findings of this study revealed a significant positive correlation between all examined variables and self-efficacy in design process practices. This correlation underscores the importance of fostering an educational environment that not only emphasizes STEM disciplines but also integrates them within the context of practical design and problem-solving tasks. These results have profound implications for educators and policymakers, especially in the realm of STEM education. They highlight the need for curriculum and pedagogical strategies that not only focus on technical knowledge but also promote creative thinking and practical application through design process practices. Such educational approaches are vital in preparing students for the challenges of a technologically advanced society, equipping them with the skills necessary for innovation, creative problem-solving, and effective design implementation.

15:00 *Christina Hutabarat* and *Reinard Primulando*

The design of STEM-based Interactive Products Aims to Enhance Creativity, Critical thinking, and Innovation Among Students at the Elementary, Junior, and High School Levels

ABSTRACT. STEM-based learning is crucial for students at all levels of education to develop critical and creative problem-solving skills. To achieve this, a comprehensive product development process utilizing the Interaction Design method is necessary. The aim of this research is to identify the needs of teachers and students across elementary, middle, and high school levels, design products using the Interaction Design method, and evaluate STEM-based interactive products. The first step in this process involves conducting interviews with teachers and students from all three levels to identify their needs. The resulting product will address environmental issues by incorporating Science, Technology, Engineering, and Mathematics concepts across these levels. Once needs have been identified, a design workshop will be conducted to explore various concepts. The project selected through qualitative and quantitative assessments will proceed to the prototype design stage. The developed prototype will be a high-fidelity prototype, allowing features and functions to operate like the actual product.

15:30 *Jennifer Long Miaw Ying* and *Goh Ho Laye*

Empowering Primary School Children in Singapore: STEM Learning as a Catalyst for Creativity, Communication, and Contribution

ABSTRACT. This paper explores the role of STEM (Science, Technology, Engineering, and Mathematics) learning in shaping primary school children in Singapore into creators, communicators and contributors to society. When engaged in STEM, students exhibit heightened curiosity, problem-solving skills, and an intrinsic motivation to explore the world around them. The study conducted at Westwood Primary School in Singapore investigates the impact of using a design thinking approach for designing an integrated STEM curriculum . The study focuses on evaluating how this integrated approach influences students' development in adaptive thinking and inventive thinking, hones their communication skills, and develops in them a sense of responsibility, care and concern for others. It investigates the impact of STEM lessons on the development of inventive and adaptive thinking, communication skills, and civic literacy among Primary 4 pupils. Two classes of Primary 4 pupils were subjected to pre- and post-implementation surveys, accompanied by pupil reflections.

The intervention included lessons on SLS as well as 4 face to face sessions of design thinking lessons for a selected group of student facilitators based on STEM lesson resources. These student facilitators provided support for their peers during the STEM lessons. Preliminary findings indicate a significant positive correlation between the application of design thinking principles and the development of these essential skills. In terms of adaptive thinking, students exhibited an increased ability to navigate uncertainties and adapt solutions to changing circumstances. Inventive thinking is demonstrated as students engaged in creative problem-solving, encouraging them to think outside conventional boundaries. Communication skills were honed through collaborative projects, enabling students to articulate their ideas effectively and engage in meaningful discourse with their peers. Students developed a heightened awareness of the societal implications of their innovations, fostering a sense of social responsibility. In conclusion, this study at Westwood demonstrates the tangible benefits of integrating a design thinking approach into the STEM curriculum, showcasing the potential to shape students into adaptable, inventive, and socially responsible individuals. Findings hold thoughtful implications for educational policy and practice, advocating for the continued integration of STEM and design thinking to prepare students for the challenges and opportunities of the future.

14:30-16:00 Session 2D

STEM learning environment

CHAIR:
Peter Mecca

LOCATION: TR702

14:30 *Yann Shiou Ong*, *Bryan Yue*, *Mendel Seah*, *Jaime Koh*, *Tan Ying Chin*, *Wee Beng Tay*, *Aik Ling Tan* and *Yong Sim Ng*

Fostering Students' Productive Interdisciplinary Engagement in Integrated STEM Activities

ABSTRACT. While STEM education continues to be a hot topic in many education systems around the world, including Singapore, STEM teachers commonly face the challenge of designing and enacting meaningful STEM activities. These teachers are presented with a diversity of definitions for STEM education, a variety of frameworks to guide them in designing integrated STEM activities, as well as observation protocols that communicate desirable ways of enacting STEM activities. However, existing integrated STEM lesson observation protocols appear to lack a coherent framework across the protocol items. Despite the protocols including a list of characteristics claimed as common across K-12 STEM classrooms and reflecting the desired outcomes of STEM education intended by the administrators/policy makers, these protocols lack guidance on how the learning environment could be redesigned to promote the intended learning outcomes of STEM activities.

To bridge this gap in the existing literature, we developed an integrated STEM classroom observation protocol (iSTEM protocol) based on the Productive Interdisciplinary Engagement (PIE) framework, which was in turn adapted from the Productive Disciplinary Engagement framework by Engle and Conant (2002). We have validated the iSTEM protocol and reported our analysis in a peer-reviewed journal

article. We have also developed an educator's version of the protocol with the STEM Learning Experience Reflection Tool 2.0 (STEM Tool 2.0).

In this presentation, we will conjecture which of the four design principles (problematising, resources, authority, and accountability) will lead to particular student outcomes, (ii) highlight and justify key revisions from the iSTEM protocol to STEM Tool 2.0; and (iii) illustrate the use of the STEM Tool 2.0 using examples of integrated STEM lessons enacted in two lower secondary (middle school grades equivalent) classrooms in Singapore. With regard to the particular student outcomes, we will focus on (a) group-based cognitive engagement, (b) interdisciplinary decision-making that is systematic and disciplinary-based, and (c) progression toward a better solution to the STEM problem. We will also suggest how the four design principles can be met to foster students' productive interdisciplinary engagement during integrated STEM activities.

15:00 *Tang Wee Teo* and *Sherwin John Mabulo*

Epistemic infrastructure of an EPIC STEM programme

ABSTRACT. This paper is a comprehensive examination of a three-year STEM (science, technology, engineering and mathematics) programme designed for 132 Grade 9 Singapore students. The programme was intended to support students in constructing their STEM portfolio by providing a range of STEM learning experiences (hackathon, inquiry project, learning journeys, symposium) that they can curate for personal use (e.g., applications into post-secondary school courses).

Students with less access to STEM capital, for example, may not have participated in STEM competitions compared to their higher ability peers, were selected. The goal of this study was to examine the epistemic infrastructure of the activities implemented to afford students opportunities to build their STEM capital. The research question was: Do the various events afford epistemic infrastructure for students to meaningfully engage in STEM learning?

Data collection included a student survey conducted right after the hackathon and at the end of the student symposium, videos of all events, student interviews at the events, and student focus group discussions after the symposium. Photographs of student artefacts and video recordings of their elevator pitches during the competition were also collected for analysis. The data were analysed using prescription codes (i.e., content, process, and apparatuses) and emergent codes (i.e., subcodes that provide clarity to the prescriptive codes). The constant comparative approach and inter-rater reliability are adopted to achieve validity.

The study explored the different affordances offered by each event and how the students adapted and adjusted their approaches to learning and doing. Preliminary findings suggest that depending on the required output of each event, students perceived, interpreted, and constructed knowledge differently within the context of the STEM activity. For instance, whilst the symposium provided a platform for them to communicate and present their ideas to the audience, the learning journey exposed them to the processes and tools of the STEM industry.

This study provides valuable insights for teachers and STEM programme organisers in designing and developing activities anchored in STEM. This work can also offer an

analytical and theoretical lens for purposeful planning and implementation of STEM programmes that afford epistemic infrastructure that value-add to students' STEM capital.

15:30 *Ray Wu-Rorrer* and *Peter Mecca*

STEM Environments In Secondary Education Sustainability Programs: A Case Study On The Application of AgroLab Framework

ABSTRACT. This review presents an illustrative case study that details the continued progression of multiple, non-traditional STEM learning environments at an urban secondary school campus. These environmental-focused ecosystems support integrated STEM learning by aligning with the United Nations Goals for Sustainable Development (SDGs). By providing for direct application of sustainability practices in STEM education through student projects and school courses/activities, the review calls attention to broader issues and topics related to environments that are supportive of STEM learning.

Beginning with an initial review of models, programs, and projects by the key stakeholders of the Falls Church City Public School's (FCCPS) sustainability program in Fall 2019, the AgroLab Uniandes emerged as a prime model for implementation in the FCCPS Academy for Sustainable Thinking during Fall 2022. The model served as a framework to streamline the efforts of the new and existing environmental science, energy, and design programs under the umbrella of an urban agriculture program focused on sustainability within the city's public schools and the adjoining community. The model's small-scale, local impact philosophy mirrors the image of the city, commonly referred to as the "Little City." Located in the suburbs and less than 10 miles from the heart of Washington, D.C., the "Little City" has maintained its community-oriented beliefs even in the face of the significant urbanization taking place in surrounding counties.

The results of the case study found that students in the FCCPS sustainability program are developing deeper understandings of urban agriculture and environmental science each subsequent year through multiple, intentional experiences that combine their classroom instruction with project based activities in the schools aquatic education facility, the vivarium (indoor greenhouse) facility, the school gardens (pollinator, native plants, food production), and living labs (water retention area designed ecosystems). Multiple exhibits are presented of the student experiences within the educational facilities.

14:30-16:00 Session 2E

STEM teacher and teacher education

CHAIR:
Karma Utha

LOCATION: TR703

14:30 *Joonhyeong Park*, *Tang Wee Teo*, *Arnold Teo*, *Jina Chang*, *Jun Song Huang* and *Sengmeng Koo*

Teachers' considerations in design and implementation of artificial intelligence (AI)-integrated science lessons

ABSTRACT. This paper presents a study that delves into the integration of artificial intelligence (AI) into science lessons. As AI is not a traditional discipline in schools, there is no standalone curriculum for it. Hence, integration into traditional disciplinary subject matter is more feasible in implementation. This involved the design and implementation of an innovative AI-integrated science lesson package, which was piloted by three Grade 7 science teachers in Singapore. This presentation highlights the primary design considerations in the AI-integrated science lesson, as well as teacher experiences with implementation.

The primary considerations behind the lesson design were to prioritise simplicity, effectiveness, and accessibility for Grade 7 students. The lesson package utilised existing AI resources but adapted to fit the curricular context, including modifications to enhance scientific reasoning.

Findings from the study unveiled intriguing perspectives from teachers. Notably, the teachers exhibited a discerning awareness of the similarities between AI and science, emphasising the mutualistic roles these two domains play in the context of problem-solving. The recognition of this complementary relationship provides a foundation for fostering a holistic understanding of how AI can be seamlessly integrated into established scientific frameworks.

However, the study illuminated significant challenges faced by the teachers, notably a perceived lack of confidence in mastering AI content and apprehensions related to adapting the curriculum to accommodate AI concepts. These challenges underscore the importance of providing comprehensive AI resources to educators, addressing not only content mastery concerns but also facilitating a smoother integration process.

This research contributes valuable insights for curriculum designers, emphasising the need for well-crafted AI-integrated lesson packages. Moreover, it sheds light on the role of science teachers in contributing to AI literacy, ultimately empowering students to navigate an increasingly AI-driven world within the existing educational framework. As AI continues to permeate various aspects of society, this study underscores the significance of integrating AI education seamlessly into established educational paradigms.

15:00 *Hamsa Venkat*, *Margaret Leahy*, *Deirdre Butler*, *Lorraine Harbison* and *Greg Smith*
Supporting integrated STEM leadership in Initial Teacher Education

ABSTRACT. In Ireland, the Primary Curriculum Framework (NCCA, 2023) presents STEM as one of five curriculum areas that structure learning at primary level. Across the framework, there is recurring reference to the need for balanced attention to teaching STEM subject concepts and skills, and teaching for integrated STEM (iSTEM) in ways that enhance and connect subject learning with real-world problem solving. While the challenge of balancing STEM disciplinary subject teaching and iSTEM is widely recognised in the literature, there is limited work on how best to prepare teachers to embed iSTEM into classroom practice.

In this paper, we document our learning from a research project in which we introduced iSTEM to a group of 85 final year Bachelor of Education (BEd) students, all of whom had specialised in either science education, digital learning or mathematics education

as part of their programme. In the project, the three specialism groups were brought together with the aim of developing the students' skills to act as 'STEM Champions' in schools. Supported by us and working in small cross-disciplinary teams over a four-week period, students researched renewable energy sources, studied the science of their generation, storage and use, and constructed a lego-based prototype of a renewable energy source and coded for its dynamic action.

Post-project, students reflected on their learning in their final assignments. We analysed these assignments with a qualitative focus on the nature of comments on the possibilities for learning through an iSTEM approach. Drawing on grounded theory methods, an inductive approach was adopted towards analysis. Key findings included: students' willingness to lead iSTEM work and recognition of the range of transversal skills developed through iSTEM projects including problem solving, critical thinking, collaboration, and that students tended to view their project experiences through the lens of their specialism. Comments frequently reflected pedagogical approaches used within specialism learning, while noting the need for balance across MST in iSTEM projects. A key implication for us is to consider our own planning and the kinds of intervention required to balance across MST in authentic ways linked to the problem situation.

15:30 *Karma Utha*, *Ugyen Pem* and *Tandin Penjor*

'The Impact of Open Educational Resources (OERs) on the Professional Development of STEM Teachers: A case of Bhutanese Physics Teachers

ABSTRACT. This study investigated the impact of Open Educational Resources (OERs) on the professional development of Bhutanese secondary school teachers, with a focus on physics. Collaborating with partner institutions in Tanzania, Nigeria, and India, Samtse College of Education developed and implemented 13 STEM modules—three each for Biology, Chemistry, Physics, and Mathematics, complemented by a shared pedagogy module. The physics modules were Force and Motion, Work, Power and Energy, and Electromagnetism, embodying the essence of STEM by seamlessly integrating physics concepts, technological tools such as videos and simulations, engineering principles in experimental design, and the application of mathematical knowledge in problem-solving. Employing a mixed-methods approach involving pre-test and post-test assessments, analysis of lesson plans, reflections, and interviews, the study aimed to find the impact of OERs on teachers' Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK), and General Pedagogy Knowledge (GPK). The research also studied the dynamics of a Community of Practice (CoP) on Telegram to elucidate knowledge-sharing patterns within this professional community. The findings revealed that the majority of teachers experienced progress in their proficiency levels, indicating a positive influence of OERs on their professional development, enhancing their content knowledge, technological skills, and pedagogical practices. However, some teachers require further enhancement in SMK and PCK, specifically in the modules Work, Energy and Power, and Electromagnetism. The utilization of a Community of Practice emerged as a commendable practice for knowledge and practice sharing. The study recommends that educational institutions actively support the Continuous Professional Development (CPD) of physics teachers by facilitating access to OERs and supplementary resources. This strategic approach holds the potential to significantly enhance teachers' Subject Matter Knowledge and Pedagogical Content Knowledge, ensuring a dynamic and continually evolving landscape for STEM education.

14:30-16:00 Session 2F

STEM teacher and teacher education

CHAIR:
Suphanwadee Prasong
LOCATION: TR704

14:30 *Chalongwoot Janhom*, *Kingdow Pongtawee*, *Chayakarn Suanboon* and *Raviporn Runajak*

Good Practices for Teachers in Designing and Facilitating STEM Learning Activities in Biology Classroom

ABSTRACT. Biology is often regarded as less conducive to the implementation of STEM activities compared to physics and chemistry. Nevertheless, a select group of biology teachers under the Office of Basic Education Commission of Thailand has demonstrated successful design and implementation of engaging STEM activities within the biological sciences. This research endeavors to elucidate exemplary practices to guide teachers in designing and conducting STEM learning in biology classrooms. Five teachers, each awarded for their outstanding instructional design activities at educational service area offices and/or national levels during the academic years spanning 2018-2023, were purposefully selected as participants. The study employed qualitative interviews to extract insights into effective practices for facilitating STEM learning. Thematic analysis was applied to distill salient themes from the interview transcripts. Findings reveal five commendable practices that contribute to the success of biology teachers in designing and conducting STEM learning experiences. Firstly, integrating learning modules grounded in existing biology-based innovations to cultivate essential STEM skills and practices. This involves guiding students in tasks such as designing a CPR machine within a lesson on the circulatory system, formulating an application for advising on antibiotic usage for strep throat within the realm of immunity, or creating a skin patch for measuring glucose levels from sweat inside the unit of endocrine system. Secondly, fostering STEM partnerships involves building relationships with specialized advisors both within and beyond the school environment, including engineers, physicians, technologists, biologists, and local wisdom experts. Thirdly, expanding instructional time by merging learning hours with other disciplines possessing congruent or complementary learning indicators. For instance, linking biology, health education and technology design. Fourthly, motivating students by accentuating the significance of their learning experiences, encouraging them to present or submit their works for publication or participation in higher-level competitions. Lastly, active immersion within a community that fosters positivity, knowledge exchange, and the provision of exemplars showcasing adept STEM activity design. This study addresses a crucial void in the literature by offering valuable insights into the facilitation of STEM education, particularly within the domain of biology classrooms.

15:00 *Amelia T. Buan*, *Vanessa B. Zabala*, *Manuel B. Barquilla*, *Joneil Medina*, *Kayce Michelle D. Casas*, *Joy R. Magsayo*, *Rica Mae B. Guarin*, *Sasithep Pitiporntapin*, *Oraphan Butkatanyoo*, *Chatsiri Piyapimonsit*, *Thananun Thanarachataphoom*, *Usanee Lalitpasan* and *Sareeya Chotitham*

Using Outdoor STEM Professional Development Workshop for Enhancing In-service Teachers' STEM Literacy in the Philippines

ABSTRACT. The objectives of this study were to 1) investigate changes in teachers' STEM literacy that occurred as a result of participating in a workshop focusing on outdoor STEM PD workshop, and 2) determine their satisfaction levels regarding the outdoor STEM PD workshop. The research participants in this study were 30 in-service teachers from public schools in the Philippines. Teachers were purposefully selected for participation in the outdoor STEM PD workshop. At the beginning of the outdoor PD workshop, they were asked to complete an open-ended STEM literacy questionnaire that measured teachers' STEM literacy in 6 components: STEM concept, STEM integration, STEM practice, STEM participation, STEM application, and STEM awareness. The program then included activities in three phases: preparation activities, a one-day workshop in a local garden, and following-up activities to link with curriculum and design activities. As a final research activity, teachers completed a satisfaction survey to determine their perceptions towards the conduct of the outdoor STEM PD workshop. Statistics for the questionnaires included descriptive statistics, standard deviation (S.D.), and a dependent t-test. The findings show that the post-test scores of teachers' STEM literacy was 12.83 (moderate level), and had increased when compared with the pre-test score of 6.87 (fair level), with a significant difference at .05. The overall teachers' satisfaction on the outdoor STEM PD program was excellent (M= 4.95, SD= 0.13). For further research, the researchers should provide additional follow-up activities to promote teachers' STEM literacy.

15:30 *Suphanwadee Prasong*, *Palakorn Prasong*, *Tharuesean Prasoplarb*, *Chatree Faikhamta* and *Akarat Tanak*

STEM & I: The Reflective-Based Collaborative Self-Study on STEM Teaching

ABSTRACT. The missing link between theoretical and practical in teaching STEM created the voids of lacking conceptualizing integration between the disciplines, which are constructed around beliefs around teaching STEM. In this study, we, one STEM teacher, one STEM educator, and one STEM school director who teaches STEM and works with STEM teachers, conducted a reflective-based collaborative self-study in order to better understand our beliefs and practices around STEM. These three members shared the common values of eagerness in STEM education and the need to achieve the next individual STEM missions, which are a STEM lesson plan, a STEM professional development program, and a STEM school roadmap by back-and-forth of taught and learned, defined as the STEM visions from STEM experiences. The data were collected from the transcription of five story-telling session videos, the participant's reflective journal of STEM visions and missions, and the three individual STEM missions, then analyzed by a combination of content analysis and inductive analysis. The results visualized the essential keys of STEM visions to develop STEM lessons. Firstly, we faced and overcame the fears of designing an unsuccessful STEM lesson through experiencing various roles of practitioner, contributor, and expert in the profession. Those different STEM missions allow us to gain a better understanding of the continuum, creating STEM challenges and gathering the opportunity for learners to learn from failures. Secondly, we emphasized the STEM orientation, focusing on STEM learners' characters with a greater understanding of the complexity of integration disciplines to reach the S-T-E-M milestone. Those kinds of learning steps help the learners reach multiple solutions and be evidence-oriented in their study. However, the three 'I' in this study provided self-practice and how-to as the systematic tools for growth in professional STEM education by individual or collaboration with others. Furthermore, the results would imply that STEM practitioners should increase

their self-esteem in teaching STEM and make more contributions with-in the STEM learning community.

14:30-16:00 Session 2G: Workshop by DOST Science Education Institute

Workshop: The DOST–SEI STEM Resources for Teaching and Learning

Presenters: Josephine S. Feliciano, Michael Telesforo

Synopsis:

The Innovations Unit (IU) of the DOST-SEI - Science Education Division and Innovations Division (SEID) develops and produce educational resources, models and strategies to support teaching and learning of science and mathematics from pre-school to Grade 12 through prints, interactive multimedia and immersive technology platforms. Among these are the DOST Courseware, Strategic Intervention Material for Teaching with Augmented Reality (SIMATAR), Virtual Laboratory Application in Science (VLAS) for elementary and high school along with Bukas-Tuklas and Storybooks for pre-school. These resources are available through the institute's download site and online stores for free. An orientation or briefing will be conducted to give overview of each of the resource. After which, hands-on activities with the participants will be conducted using the SIMATAR to be followed by synthesis, Q and A, and distribution of free kits.

LOCATION: TR705

14:30-16:00 Session 2H: Workshop by LD Didactic GmbH

Workshop: Networking Interfaces for Digital STEM Education

Presenter: Dr. Andreas Kastner

Synopsis:

Digital technology is meanwhile widely used for teaching – anyhow in most cases only in an one-dimensional way: digital documents are replacing books, instead of writing on a paper it is writing on a tablet, instead of connecting a device via USB you connect now via Bluetooth.

The many additional advantages are rarely used. One possible advantage – networking interfaces – should be viewed under different perspectives:

1. Preparation of a cloud-based teaching unit which combines different digital (but also analogue) technologies together – including networking devices. The used worksheets are bidirectional, i.e. they can configure the device for the experiment already and also they can record the data directly into the worksheet, where there are exactly the tools prepared, which are needed for evaluation of the data.

2. Networking interfaces from the view of the teacher: the teacher has always the view to all interfaces at the same time. He/she has the possibility to assist the student individually directly from his workstation, which could be a PC, a tablet or just his mobile phone. After the experiment he can collect and compare the measurements of the different groups and discuss about the results. By selecting different parameters for each group physical laws can be impressively demonstrated.

3. Networking interfaces from the view of the students: in current technologies one interface can deliver its data only to one device – either via USB or Bluetooth. Networking interfaces can share measurement results to a whole group of students. So even a group of students is working with the same equipment, everybody in the group has the possibility of an individual evaluation and interpretation of the measured data. So the important soft skill of teamwork is combined with an individual evaluation of each student.

All this functionality is embedded in an open system, which allows sharing teaching units between the teachers. It is also possible to network teaching institutes together and organize equipment in a cost-efficient way or implement experiments within curricula as teaching units in a very fast way.

LD Didactic GmbH digital teaching solutions link laboratory equipment, experimental manuals, content management experiment preparation, experiment execution and evaluation to one platform with the use of networking interfaces.

LOCATION: TR706

16:00-17:30 Session 3A

History, philosophy, epistemology, and nature of STEM and STEM education

CHAIR:
Yuya Nakanishi
LOCATION: 7A-01-07

16:00 *Sean Buckreis*

Mathematics Education and the Centrality of Experience: Crafting Aesthetic Experiences

ABSTRACT. In Experience and Education (1938/1988), John Dewey asked a poignant question: “How many lost the impetus to learn because of the way in which learning was experienced by them” (p. 12)? This has certainly been an issue with which educators have been wrestling for years. How can we, as teachers, engender the impetus to learn? In this presentation I offer a response informed by the work of John Dewey and his theorizing on aesthetic experiences.

Although the term aesthetics often conjures up images of artistic works or thoughts of critical judgements of art, Dewey's conception of the aesthetic is more focused on the centrality of experience for the individual. Dewey (1934/1987) was dismayed that "art is often identified . . . apart from human experience" (p. 9) and seeks to go "back to experience of the common . . . to discover the esthetic quality such experience possesses" (p. 16). I share many of Dewey's ideas and argue that his way of thinking about an aesthetic experience—as uncovering the aesthetics inherent in everyday life—can offer insights for mathematics education, opening new ways to envision teaching and learning.

In this exploration of the relationships I see between Dewey's concept of the aesthetic and mathematics education I begin with the traditional and historical connections between mathematics and aesthetics. Next, I offer Dewey's ideas on aesthetics as an alternative perspective. From there I move to an overview of my experiences as a mathematics teacher and as a university professor working with pre-service primary and secondary teachers. Throughout, I put forward what I understand to be the curricular implications of Dewey's sense of the aesthetic as they pertain to mathematics and STEM education. Every experience has the possibility of being an aesthetic experience—if treated the right way, the ordinary has the possibility to be transformed into the extraordinary.

16:30 *Janne-Marie Bothor* and *David-Samuel Di Fuccia*

Linking Scientific Content with Engineering Contexts to promote Nature of Science (NOS) and Nature of Engineering (NOE)

ABSTRACT. In order to participate in society, it is necessary to recognize and understand the scientific, engineering and technological content and applications in everyday life. To do this, students need an understanding of both natural sciences (NOS) and engineering (NOE). Such an understanding can be fostered by an explicit and reflexive instruction of overarching contexts. Engineering content as well as its ways of thinking and working have little relevance in German science teaching. In addition, there is little involvement of engineering in all areas of school education. This is due to a lack of discussion in the education standards. In addition, teachers have insufficient ideas about the relevance and possibilities of implementing engineering content into the classroom. This is justified by the fact that engineering contexts require an understanding of diverse scientific content and this complexity often leads to cognitive overload. Therefore, a precise analysis of engineering contexts and a didactic reduction to the necessary scientific content is required in order to prepare it in a way that is understandable for students. In this study, interdisciplinary projects were developed in a university learning environment by 8 pre-service science teachers in cooperation with engineering students. The projects were developed in several stages, in which didactic decisions were made, which are analysed in this study as a course of development. In addition, the developed concepts and didactic descriptions of the projects were examined from the point of view of content analysis and the links between the interdisciplinary contents were determined. It was also investigated to what extent the content were linked and explicitly addressed in a teaching-learning laboratory. The results show that the pre-service science teachers succeed in identifying interfaces between science and engineering and in linking them appropriately theoretically. The pre-service science teachers had difficulties in identifying the appropriate scientific content in the projects and in achieving a didactic reduction to the essential contents.

17:00 *Yuya Nakanishi*

STEM Education in the Late Meiji Period in Japan: A Historical Perspective on the Integration of Engineering Fields in Science Education

ABSTRACT. During the Meiji Period of Japan, the national policy aimed to make the country more prosperous through the development of its industries. In particular, plans were made to develop engineering as a form of business education in addition to agriculture and commerce. However, these initial efforts showed little success with the fewest number of people choosing to enter engineering fields. The intention was to increase the number of engineering professionals by breaking away from the history of learning in the industrial field, which had been conducted exclusively through the traditional apprenticeship system. In other words, the aim was to create an education for specialists based on education for all. Today, the integration of science education and engineering fields is desired, although the background and significance are different, there are many perspectives to be gained from history. In order to clarify why and how the study of engineering fields should be conducted in science education, I examined it from a historical perspective. Based on the above, the following two research questions were set. 1. What were the objectives of science education during the Meiji period? 2. How was the content of industrial fields included in science textbooks during the Meiji period? The research methodology employed a literature survey utilizing materials published by the Ministry of Education and national textbooks from the Meiji period. The analysis focused on elementary school science. During this period, elementary school enrollment increased from 30% to 98%. The results of the research revealed that technological education was implemented to promote engineering. As part of the slogan "wealthy nation, strong army," the government wanted to educate people about technology so that more people would become experts in the engineering field. However, while elementary schools addressed underlying principles and concepts using familiar examples, specialized vocational education was not imparted at this level. Elementary school science textbooks contained information on the workings of devices like telephones and streetlights, yet it was not until the early Showa period that diagrams and drawings were incorporated. Textbooks from the Meiji period utilized simple diagrams and pictures, mainly relying on textual descriptions.

16:00-17:30 Session 3B

STEM curriculum and teaching

CHAIR:
David Nutchey
LOCATION: TR701

16:00 *Hwee Sim Claire Poh*

Exploring Pedagogies, Strategies and Tools in STEM Curriculum

ABSTRACT. STEM education is essential in addressing the demands of an evolving world. With a growing emphasis on STEM education, STEM curriculum design is crucial as it empowers teachers to shape educational experiences that cultivate essential skills for students' future success. It enables teachers to craft engaging lessons that promote critical thinking, problem-solving, and interdisciplinary connections, providing students with the tools needed to navigate an increasingly technology-driven world. Through effective curriculum design, teachers play a pivotal role in preparing

students for future careers and instilling a passion for lifelong learning in STEM subjects.

The study analyses the pedagogical practices of a teacher with a participating class from a school in a small village outside Prague, catering to a capacity of 90 students from Grades 1 to 8. The teacher devised a mathematical inquiry to foster students' understanding of statistical concepts and use statistical analysis and mathematical models to interpret data. Within a broader framework of STEM, a specific focus is on the context of leveraging technologies like cameras and sensors to analyse driver behaviour. The approach is in line with an inquiry-based teaching framework designed to reinforce an in-depth understanding of STEM concepts through fostering curiosity, active participation, and a sense of ownership in learning.

On reviewing the above study, the following key considerations in STEM curriculum and teaching were brought into focus:

1. The role of mathematics pedagogy within the integrated STEM framework: Fosters students' understanding of mathematics and its close connections within STEM. 2. Guided inquiry-based approach: Highlights the importance of setting up an environment conducive to the exploration and understanding of STEM principles. This strategy helps students formulate understanding and make connections to tasks and knowledge learning. 3. Teachers as facilitators: Guided by constructivist reasonings and informed by their pedagogical content knowledge (PCK), teachers adapt and transform content according to students' level of understanding. 4. Teaching as a thought-driven decision-making process: Engages Knowledge Quartet framework of analysis to evaluate teachers' pedagogical practices within the STEM teaching context.

The study discusses pedagogical approaches, strategies, and tools, describing their key roles in effective STEM instruction.

16:30 *Don Yeo Shyh Yuan*

Exploring Pedagogies, Strategies, and Tools for Enhanced STEM Learning Experiences

ABSTRACT. Integrating STEM subjects allows students to see the connections between different disciplines, promoting a holistic understanding of concepts rather than isolated knowledge. By incorporating STEM into classroom activities, it cultivates skills and mindsets crucial for success in an increasingly complex world. These activities mirror societal challenges and prepares students to apply scientific principles and technology to explore solutions to problems in unconventional ways.

This presentation delves into the realm of STEM curriculum design and enactment, focusing on two aspects in designing STEM learning experiences which is to provide opportunities for application and opportunities for integration. Strategies such as differentiated instruction, interdisciplinary approaches, and project-based assessments are also examined to discern their impact on student learning outcomes and engagement in STEM subjects. The exploration and evaluation of diverse pedagogies, strategies, and tools utilized in crafting STEM activities will also be discussed.

A sample STEM activity will serve as an example to showcase the application of the integrated S-T-E-M Quartet Instructional Framework in guiding the design and

implementation of a learning experience for a cohort of Chemistry students in a High School setting. Using Road Safety for Platform Workers as a theme, this creates opportunities within the curriculum to address the meta-knowledge and humanistic knowledge developments in 21st century learning. Students get to develop an understanding of users, consider the environment that the users live in and interact with various elements in their environment, and empathise with the unique challenges that users face individually and as a community.

By synthesizing findings from the implementation of these learning experiences, this presentation aims to offer insights into best practices and recommendations for educators seeking to innovate and optimize STEM education through curriculum design and enactment.

17:00 *David Nutchey*

Connected thinking: Integration based upon students' cognitive processing across subjects of the Indonesian curriculum.

ABSTRACT. In Indonesia there is much interest from schools in the concept of STEM, although exact definitions of STEM vary as do approaches to coordinate, collaborate, or integrate learning across the STEM subjects. In the past, attempts to integrate learning across STEM subjects in Indonesia have been restricted by the structure of the curriculum and various government policies and regulations. However, in recent years the Indonesian schooling system has undergone significant changes, including the introduction of the new Kurikulum Merdeka or Independent Curriculum. The new curriculum specifies overarching aims and end-of-phase achievement standards for each subject that more explicitly include inquiry-oriented ways of working and learning. From this, schools are expected to define and sequence learning objectives that guide the development of students' understanding and skills regarding each subject's content. In comparison to its predecessor, these features of the curriculum provide schools and teachers with more flexibility and afford opportunities for the integration of learning across the STEM subjects. Against this background of curriculum change and adopting a design-based research approach to curriculum enactment, this paper presents the analysis of the Indonesian curriculum documents and the definition of subject-level learning objectives based upon the new taxonomy of educational objectives provided by Kendall and Marzano. The subject-level objectives reflect the many similarities in the intended ways of working across the Science, Technology, Mathematics and Science subjects, including Social Science, whilst also allowing for the representation of the unique differences of each subject. This affords the alignment and integration of learning based upon students' cognition (or thinking) and the development of their associated understanding in relation to the subject-matter of each subject. This contrasts to approaches for STEM integration that focus primarily upon the selection and coordination of content and shape learning around a question or problem, often in the form of project-based learning, through which students' understanding of the content develops. It is claimed that the integration of learning based on cognition rather than content may afford Indonesian schools more natural and authentic identification of suitable themes, questions, and problems upon which to base learning within and between subjects.

16:00-17:30 Session 3C

STEM learners and learning

CHAIR:

Daiki Nakamura

LOCATION: TR702

16:00 *Sasithep Pitiporntapin*, *Oraphan Oraphan Butkatanyoo*, *Chatsiri Piyapimonsit*, *Thananun Thanarachataphoom*, *Sareeya Chotitham* and *Usanee Lalitpasan*

Using Outdoor-STEM Activities to Promote Students' STEM Literacy

ABSTRACT. This research aimed to examine the STEM literacy of students who learned through outdoor STEM activities in a different context: elective subject, extracurricular activity, and student club. The participants of this study were 29 students in elective subject, 37 students in extracurricular activities, and 48 students in a student club. The research instrument of this study was a STEM literacy test. There were 6 open-ended questions to examine students' STEM literacy in 6 components: STEM concept, STEM integration, STEM practice, STEM participation, STEM evaluation, and STEM awareness. A one-way analysis of covariance (ANCOVA) was used to examine the impact of classroom conditions while controlling for pretest scores. The finding revealed that the mean scores of students' STEM literacy after learning of three groups were significantly different at.01. Students who learned outdoor-STEM activities in the elective subject had a higher mean score of STEM literacy after learning higher than students who learned outdoor-STEM activities in extracurricular activities with significant different at.05. In addition, students who learned outdoor-STEM activities in student club had a mean score of STEM literacy after learning (M=16.18, SD=0.57) higher than students who learned outdoor-STEM activities in an extracurricular activity (M=10.53, SD=0.57) and in the elective course (M=12.99, SD=0.57) with significant different at.01. These findings provided recommendation for teachers' using student club with outdoor-STEM activities to promote students' STEM literacy.

16:30 *Chung Oi Kok*

Development of STEM skills through robotics

ABSTRACT. The education research community reported that critical thinking skills, problem-solving skills, flexible thinking skills, collaboration skills, and communication skills have been identified as key STEM skills by the STEM industries through their research. Among all these skills, critical and problem-solving skills are ranked as the most essential STEM skills. They can be developed in any of the educational settings from preschool, primary school, and secondary school through learning core subjects such as science and mathematics. Robotics can also be a learning tool to develop these STEM skills. Presently, in Singapore, some preschools have adopted robotics for preschool children to learn science concepts and to develop discovery, inquiry, and investigative skills to support discovery learning. Nevertheless, through in-depth analysis, critical and problem-solving skills are manifested in such a discovery learning process. A recent research study showed that a group of preschool children developed discovery, inquiry, and investigative skills by learning science concepts on a real fishing rod through a robotic fishing fish. The research was conducted based on quantitative research on documentary analysis in search of relevant literature to define the pattern behaviors of discovery, inquiry, and investigative skills, and qualitative research, a classroom observation to examine if these skills were manifested through the robotics program. Nevertheless, through a deeper analysis of the research study, these preschool children further developed critical thinking and problem-solving skills

during the learning process. The goal of this paper is to discuss how critical and problem-solving skills are manifested in the discovery learning process for preschool children. It is based on an extended research study to conduct an in-depth examination of how the discovery learning process allows children to manifest critical and problem-solving skills. This study shall be carried out by reviewing relevant literature reviews to find out certain behavior patterns that show the manifestation of critical and problem-solving skills through the discovery learning process. The results will imply that critical and problem-solving skills are manifested and can be developed along with other development of skillsets, in this case, discovery, inquiry, and investigative skills.

17:00 *Shotaro Naganuma*, *Daiki Nakamura*, *Mai Okabe*, *Kodai Miura*, *Mikiharu Ishitobi* and *Soichiro Kudo*

Interests in Science and Technology-Related Topics Among Three Distinct Attitudinal Groups

ABSTRACT. Regardless of their liking or disliking science, conducting interesting lessons for students is a key goal in science education. However, in Japan, there has been insufficient analysis of which science- and technology-related topics might interest students who dislike science. Therefore, we used data from the Relevance of Science Education-Second (ROSES) survey, conducted using a stratified probability proportional cluster sampling method targeting ninth-grade students, to identify topics of interest with small variance among groups. We categorized 3,297 students into four groups—Specific Priority (N = 1,268, 37.1%), Other Priority (N = 1,137, 33.3%), Poor Priority (N = 837, 25.8%), and Not-Positive Priority (N = 55, 1.6%)—based on their positive or negative responses to the two items in ROSES: “School science is interesting” and “I like school science better than most other subjects.” Excluding the Not-Positive Priority Group owing to its small ratio, we compared three groups’ interests in 78 topics under “What I want to learn about” in ROSES. The results were as follows. First, the Specific Priority Group showed the highest interest in 75 topics, whereas the Poor Priority Group showed the lowest interest. Second, for 60 items, students showed interest in studying. Third, we observed that among the 60 items, some had smaller effect sizes than others, meaning students are more equally interested in studying these items. Finally, several items with higher interest and smaller effect sizes were identified, which can be candidate topics to deal with in the science curriculum because students are almost equally interested in studying those items despite their groups.

16:00-17:30 Session 3D

STEM teacher and teacher education

CHAIR:
Tara McDougall
LOCATION: TR703

16:00 *Shoubao Gao*, *Feiyue Wang*, *Zhining Yang* and *Qishuai Li*

Teachers’ view, experience and self-empowerment towards integrated STEM education in China

ABSTRACT. In recent years, integrated Science, Technology, Engineering, and Mathematics (STEM) education has been positioned as an appropriate educational approach to address the challenges of today's society. Teachers' competence could be a key element for the successful implementation of integrated STEM education.This

study examined Chinese teachers' view, experience, self-empowerment, attitudes, and confidence with implementing integrated STEM education in Chinese classroom settings. The adaptation of an instrument that evaluates teachers' perceptions of integrated STEM education has been validated in Thailand. Data were collected through an online survey completed by 170 teachers in Shandong province in China, as well as Semi-structure interview with 8 teachers from different teaching level. The test scores were calibrated and equated using Rasch analysis. The results revealed that the participating teachers tended to have positive attitudes toward integrated STEM education. They believe that integrated STEM education is important, but lack confidence in good STEM courses. Novice teachers have higher self-empowerment than experienced teachers, and they are more inclined to turn to their school and colleagues for help when they encounter difficulties. Therefore, schools should carry out corresponding professional training and provide adequate teaching resources. The paper concludes by discussing the potential challenges of integrated STEM education in China based on the results of this study. Several implications are provided for future research.

16:30 *Panalee Satikram*, *Pattamaporn Pimthong* and *Jeerawan Ketsing*

Teachers' View toward Disciplinary Language Use in STEM Disciplines

ABSTRACT. Disciplinary language is a communication mediator in a specific context, while each discipline has its unique language. The integrated discipline, such as STEM, includes different disciplinary languages working together. People who can use disciplinary language will have a fundamental to access and communicate their knowledge to others. This case study aimed to investigate teachers' views toward disciplinary language use in STEM disciplines. The participants were two science teachers and a technology teacher from a large secondary school in Bangkok, Thailand. Data were collected by semi-structured interviews and were analyzed by thematic analysis. The results found that science teachers' views towards scientific language use related to the specific vocabulary and representations that stimulate explanations, consistent with science teaching goals that focus on student's knowledge and understanding and the application to their real life. Meanwhile, the technology teacher's view towards technological language use involves using specific vocabulary, commands, processes, or methods related to programs and designs. This is associated with the goal of technology teaching that focuses on students using knowledge and skills to design programs according to the intended purpose. These findings provide information on the role of disciplinary language that promotes or inhibits students' understanding and contributes to the teaching and learning disciplinary language related to STEM.

17:00 *Tara McDougall* and *Michael Phillips*

Shifting the Lens: Exploring the Evolution of Pre-service Teachers' Epistemic Frames in Online STEM Education

ABSTRACT. The Monash Virtual School (MVS) represents an innovative approach in delivering free online STEM education to K-12 students, particularly focusing on disadvantaged and underrepresented young women. Diverging from typical studies on online STEM education's impact on students, our research shifts focus towards future educators, examining their evolving knowledge, skills, values, identities, and epistemologies. Central to our study is the concept of epistemic frames, crucial for developing and refining MVS's interactive, team-taught lessons. We adopted Quantitative Ethnography (QE), integrating quantitative and qualitative methods, and

used Epistemic Network Analysis (ENA) for in-depth insights into pre-service teachers' professional growth. Our investigation began by assessing the strength of connections within individual pre-service teachers' epistemic frames, then exploring collaborative dynamics between teacher pairs. Data was collected via semi-structured interviews before and after teaching experiences, analysed using ENA web tool, version 1.7.0. Preliminary findings showed significant developments in the teachers' epistemic frames, prompting further interviews across the academic year. These revealed five key situated learning processes: induction, transferability, interdependence, synchronicity, and negotiability, each instrumental in the observed shifts. This research highlights ENA's limitations and the necessity of closing the interpretive loop in QE. It also underscores the importance of preparing future educators and the value of integrated research methodologies.

16:00-17:30 Session 3E

Sociocultural issues in STEM Education

CHAIR:
Al Besmonte

LOCATION: TR704

16:00 *Yohan Hwang* and *Kongju Mun*

Reconceptualizing risk education for STEM curriculum design

PRESENTER: *Yohan Hwang*

ABSTRACT. We are exposed to many risks in present and future. The risks we are exposed to are not only from natural disasters such as earthquakes, volcanoes, and droughts, but also from 'manufactured risks' caused by human activities. Ulich Beck says that most of the risks in modern society are caused by technology. This suggests that any citizen needs to have the ability to recognize, anticipate, assess, and rationally respond to risk. However, students sometimes express fear of the advancement of science and technology. For this reason, it has been argued that science education should actively introduce the concept of risk to differentiate itself from other subjects. Recently, several researchers have made the case for addressing risk education in science education. There are also recent studies that suggest that the risks of science and technology should be taught in conjunction with SSI (Socio-Scientific Issues) education. Teaching people to respond rationally to risk requires more than the traditional SSI approach of exploring issues and reconciling different positions to make decisions. To be able to design various risk education curriculum in the STEM field based on SSI and science education, it is necessary to analyze and reconceptualize the concept of risk education as it is currently used in various contexts. This study aims to analyze and reconceptualize the previous studies on risk education for STEM curriculum design. For this purpose, we collected and analyzed previous studies using keywords such as risk, disaster, and risk assessment. As a result, we reconceptualized risk education as including the following three domains. 'constructivist perception of risk', 'ability to interpret risk analysis results', and 'understanding of uncertainty in science, technology, and society'. Based on our findings, we propose that it is important for STEM education to provide problem-solving situations that enable students to take an integrated approach to risk rather than the traditional dichotomous approach and to develop teaching and learning strategies that enable students to understand uncertainty in science and technology and society through data analysis.

16:30 *Siying Xia* and *Tang Wee Teo*

Theorising a supportive framework for equity literacy in STEM learning

ABSTRACT. Viewed as an equitable solution for STEM marginalised populations, productive integrated STEM learning experiences have the potential to positively influence adolescents' STEM identity-building, literacy development, and pursuit of STEM pathways and careers. However, the existing structural conditions do not necessarily support equitable and meaningful engagement for all learners. More targeted support for tackling systemic and structural inequities needs to be explored. To centre equity and justice in integrated STEM educational practices, this paper proposes a supportive framework for empowering equity literacy. The framework defends the rightful presence of every student in STEM education, particularly underprivileged groups, and their surrounding peers. A systematic review of the relevant literature on equity literacy, equity in STEM, and liberation pedagogy was conducted. Informed by Sewell's theory of structuration, this supportive framework illuminates that developing equity literacy should be a systemic, dynamic, and interdependent progression. Specifically, equity literacy is positioned as the internal schema within the structure, shaped by “agency towards equity” that emerges from the interactions between structures and actions. The four interrelated competencies required for equity literacy proposed by Gorski are conceptualised as four progressive dimensions of actions to empower equity literacy. Advocated in Pedagogy of the Oppressed, Paulo Freire's liberation pedagogy provides practical strategies for specific actions. In this framework, the construction of equity-oriented structures enables liberation actions, and these practices could achieve the reproduction of equitable structures. This paper provides an emerging research lens for inclusive STEM education and contributes to informing practices that direct individual equity literacy towards community-wide commitments to equity and justice.

17:00 *Al Besmonte* and *Rowena Zoilo*

Safe Farming and Fishing by Knowing Physics: Capacity Building for Fisherfolks and Farmers in Santo Domingo, Albay, Bicol, Philippines

ABSTRACT. Lightning is a powerful and potentially dangerous force of nature that can pose significant risks to individuals engaged in outdoor activities, including farming and fishing. In the Philippines, it is crucial for farmers and fisherfolks to have a good understanding of the science behind lightning in order to stay safe. This paper presents a training program aimed at providing 755 local farmer and fisherfolk-participants with the knowledge and tools they need to minimize the risks associated with lightning while working in the fields or out at sea. The safety of farmers and fisherfolks is of paramount importance, and being aware of the science principles behind lightning is a critical aspect of ensuring their well-being. By understanding the science behind lightning, individuals can make informed decisions and take appropriate precautions to protect themselves and others during thunderstorms. The paper also discusses the educational attainment of the participants, the effectiveness of the training program, and the challenges faced in implementing the program. It concludes by emphasizing the need for continued support and collaboration with local authorities to ensure the long-term success of the training program and its impact on the safety and well-being of farmers and fisherfolks in the community.

16:00-17:30 Session 3F: Symposium

Symposium

LOCATION: 7A-01-06

16:00 *Tang Wee Teo*, *Lilia Halim*, *Nurazidawati Mohd Arsad*, *Chatree Faikhamta*, *Tharuesean Prasoplarb*, *Pongsatorn Panyanukit* and *Kornkanok Lertdechaphat*

Entrepreneurship in STEM Leadership and Teaching: Insights from Malaysia, Singapore and Thailand

ABSTRACT. Entrepreneurship entails thinking and acting on possibilities beyond the typical space in which one typically operates. STEM (science, technology, engineering and mathematics) education has emerged as an entrepreneurial space for school leaders and teachers in recent years as border crossing from conventional monodisciplinary departments into the integrated space where diverse disciplinary content, practices, and dispositions have become frequent. While Asian economies have taken a cue from the U.S. on promoting STEM education to meet 21st-century demands, the former have interpreted the construct of "STEM" differently and taken on STEM education in its own capacities and to a different extent in diverse settings. This symposium will shed insights into how school leaders and teachers interpret, enact, and tackle STEM education in three economies: Malaysia, Singapore and Thailand. Case studies involving interviews with one school leader and teacher from each of these economies were conducted. All the interviews were recorded online and transcribed for analysis. Qualitative methods were used to code the data and constant comparative approaches were used to analyse all six sets of data. The presentations will interest researchers, scholars, practitioners, and policymakers interested in learning more about STEM education from the stakeholders' perspectives, specifically, school leaders and teachers, who have actively engaged in leading the school and enacting STEM curriculum.

16:00-17:30 Session 3G: Workshop by Spectra-Teknik (S) Pte Ltd

Workshop: Sensor technology for the Classroom

Presenters: Vinnie Sim and Kristin Goh

Synopsis:

"The advance of technology is based on making it fit in so that you don't really even notice it, so it's part of everyday life" - Bill Gates

Sensors are used everywhere in our everyday lives, for example in the monitoring of the fridge temperature or in the monitoring the humidity in a building. With the increased need for measurement and advancement in technology, the cost of production of sensors has reduced significantly over the years providing consumers access to high quality sensors at affordable prices. As such, educators now are able can introduce various types of sensors into the classroom and expose students earlier to the various sensor technologies available in the market. In this workshop, we will explore the various sensor technologies and the instruments available in the marketplace which educators can use and introduce into the classroom.

The topics we will cover in this workshop are as follows:

(1) Temperature measurement and the sensors available

(a) Temperature monitoring methods and instruments for:

(i) Basic monitoring

(ii) Datalogger monitoring

(iii) Cloud (IoT) monitoring

(b) Case study (I): Cold Chain Monitoring and the temperature sensors involved

(c) Case study (II) : Vaccine Cold Chain solution

(2) Humidity measurement and the sensors available

(3) Wind Speed measurement and the sensors available

(4) Light measurement and the sensors available

(5) Moisture measurement and the sensors available

(6) Water Quality measurement and the sensors available

(7) Case study (III): From Farm to Fork – The Journey through High Tech Farming and the sensors involved

LOCATION: TR705

PROGRAM FOR FRIDAY, JUNE 28TH

09:00-10:30 Keynote 2: Jinwoong Song

Separately and Together: The Dilemmas of STEM Education

Today, STEM education has become an irreversible global trend. It has become a ‘slogan’ for reforming current school and university education in both so-called developed and developing countries. STEM education is similar to the STS education of the 1980s and 1990s in that it emphasizes its integrated approaches and social contexts, but is different in that its core subjects go beyond science to include mathematics and engineering. In addition, the dilemmas surrounding the nature and methods of STEM education still continue. The first dilemma is whether the focus of STEM education should be on expanding its scope in curriculum or reforming its essential methods in teaching. The second dilemma is that mathematics, science, and engineering, the components of STEM, have not only common features but also significant differences in their natures. If we emphasize the common features, it is easy to miss the nature of individual disciplines, and vice versa. The third dilemma is that the nature of each individual discipline itself has been fundamentally changing through the second half of the 20th century. What STEM educators think of as their respective fields of study is no longer consistent with that of the 21st century. In this presentation, I will look back on the historical developments of emphasizing the social relevance of science in school education, compare the features of STEM disciplines, and explore its practical future direction by focusing on the ‘participation and action’ dimension of STEM education.

LOCATION: LT1

10:30-11:00 Tea Break

11:00-12:30 Keynote 3: Choy Ban Heng

Noticing Affordances for Developing Integrated STEM Mindsets through "Day-to-Day Classroom" Mathematics Tasks

There have been calls for Science, Technology, Engineering, and Mathematics (STEM) educators to design learning experiences around authentic integrated STEM tasks—those that involve two or more disciplines—to empower our learners to develop productive mindsets or habits of mind necessary for navigating through a highly complex and uncertain world. Much of our efforts revolves around designing integrated STEM tasks that centre around solving a complex persistent problem, developing and enhancing existing solutions, or designing for specific users in different contexts. Designing and implementing such integrated STEM tasks poses several challenges for teachers and such approaches often engender a polarising discourse between integrated STEM tasks and "day-

to-day classroom" tasks. This gap between integrated STEM tasks and "day-to-day classroom" tasks is even more evident in mathematics classrooms. With the aim of developing productive integrated STEM mindsets, I wonder if we can challenge this limiting thinking and re-envision how affordances of "day-to-day classroom" mathematics tasks can be harnessed differently. In this presentation, I will add to this ongoing conversation by considering and illustrating how these "day-to-day classroom" mathematics tasks can complement integrated STEM tasks to make STEM learning an integral part of everyday mathematics learning experiences.

LOCATION: LT1

12:30-14:00 Lunch and Poster Session

12:30-14:00 Session P: ISTEM-Ed Poster Session

ISTEM-ED Poster Session (Concurrent with Lunch Break. Ignore the specific times for each poster presentation: the joint poster session is from 12:30 - 14:00)

LOCATION: Outside LT1

12:30 *Chi-Ruei Tsai*, *Chung-Yi Cheng* and *Po-Yu Tseng*

Visual Perceptual Style and Cognitive Executive Functions as Predictors of Hand Tool Skills in STEM Hands-on Learning

ABSTRACT. Contemporary STEM education emphasizes the importance of a dual-track approach that integrates hands-on learning with STEM declarative knowledge. Cognitive executive functions serve as the foundation for individuals to exhibit cognitive flexibility, respond to environmental stimuli, and achieve behavioral goals. Previous research has categorized cognitive executive functions into three components: inhibition, updating, and shifting, which facilitate cognitive behavioral inhibition, monitoring existing cognitive processes, updating new information, and shifting individuals' mental focus and attention. During hands-on STEM learning, students' use of hand tools may lead to conflicts between personal tool usage habits and STEM knowledge. Additionally, individual differences in visual perceptual style may influence their sensory perception during hands-on activities. This study aims to investigate the relationship between individual visual perceptual style, the three cognitive executive functions (inhibition, updating, and shifting), and hand tool skills. The study involved 110 upper-grade elementary school students who participated in a screwdriver-based linkage structure project. As a warm-up game, participants completed the Embedded Figures Test, Simon Test, and Running Span Task. For the linkage structure toy project, participants were provided with popsicle sticks, screws, nuts, a hand drill, and screwdrivers to freely create linkage toys. Finally, researchers used an electronic screwdriver to measure the torque value of each screw, assessing whether the participants' use of screwdrivers to complete the linkage structure demonstrated optimal motor skill performance. The findings revealed significant positive correlations between visual perceptual style and CEFs, which further influenced motor skill performance.

12:38 *Khanh Tran* and *Lynn Bryan*

Seeding New Possibilities: Culturally Nurturing Pedagogy in STEM Education

ABSTRACT. What does it mean to learn science and engineering in ways that empower youth? This poster presentation introduces culturally nurturing pedagogy as a theoretical conception and pedagogical possibility for framing K-12 integrated STEM education (specifically, the teaching and learning of science through the integration of science and engineering design). From an analysis of the affordances and shortcomings of the notion of culturally sustaining pedagogies in science and STEM education (Alim & Paris, 2017; Ortiz & Ruwe, 2022; Paris & Alim, 2014), we critique how learning and participating in science and engineering epistemologically contradicts culturally sustaining pedagogies as a theoretical conception. In particular, scholarship in the sociology of education and critical science education is cautious about the intellectual negotiation for youth who experience tension with science culture embedded with Eurocentric ideologies, values, and beliefs (Aikenhead & Jegede, 1999; Bang et al., 2012; Harding, 2001; Henderson, 2022) Drawing on scholarship in ethnic studies, integrated STEM, and social justice science pedagogy, we articulate what it means to be culturally nurturing in teaching K-12 science and engineering. We also emphasize the shifting need towards an onto-epistemological landscape that reflects the multiple realities and sense-making of our pluralistic global societies. Further, we highlight three dimensions of culturally nurturing pedagogy in science and engineering education: (1) science and engineering learning as culturally ladened and socially negotiated, (2) Ethnic Studies as the seed for multiple epistemologies to science and engineering, and (3) STEM integration as the catalyst to community and social transformation. We offer exemplars to contextualize how these dimensions may be woven into a curricular system and present preliminary findings that illustrate the dimensions. This work has implications for STEM teacher education research and STEM teacher preparation in contextualizing K-12 STEM teaching that cultivates students' cultural, historical, and social identities while participating in science and engineering practices. Moreover, culturally nurturing pedagogy in STEM education calls for ways to situate and cultivate the livelihood and well-being of our youth in ways that reflect, meet, and honor the growing need for pluralistic global societies.

12:46 *Szu-Chun Fan* and *Hsing-Yu Lan*

Mathematical Exploration in K-12 Engineering Design Activity: Predictive Analysis of Hydraulic Robotic Arm

ABSTRACT. "The Hydraulic Robotic Arm" is a popular course topic in STEM education, and lesson plans centered on this theme can often be found across various learning stages from K-12. The focus of the hydraulic robotic arm curriculum varies at different learning levels, with elementary and middle school courses typically revolving around creative or simple functional design and construction. However, at the high school level, emphasis should be placed on improving the precision of hydraulic robotic arm design. It is crucial to assess the parameter requirements of various mechanical designs through the predictive analysis of the working range, thus providing valuable reference data for practical applications. The purpose of this article is to integrate the principles of trigonometric functions from the mathematics curriculum and explore how the components of a hydraulic robotic arm can be designed precisely based on task requirements. The goal of the study is to achieve accurate control of the hydraulic robotic arm to reach specific working positions, avoiding a trial-and-error approach to adjustments during physical fabrication. The article will first define a simulated working scenario and discuss how, by adhering to the conditions and constraints of the working scenario, a set of hydraulic robotic arm mechanisms, including a gripper,

vertical arm, horizontal arm, and rotating platform, can be designed using mathematical computations. It is hoped that teachers can use the findings of this analytical case study as a reference for designing instructional activities in STEM courses with a focus on engineering design, thereby deepening the application of mathematics in engineering practice.

12:54 *Jessamyn Marie Yazon* and *Marufie June Limpin*

Nurturing STEM Talents Through I-STEM Internship Programmes

ABSTRACT. This presentation focuses on an evaluation of a science internship or immersion programme for secondary students who are talented or gifted (i.e. with high aptitude) in Science, Technology, Engineering, & Mathematics (STEM). The internship exposes learners to real world, work contexts through mentorship under topnotch scientists and engineers within professional research institutions. Defined as experiential learning, internships provide unique opportunities for acquiring scientific and technical knowhow, and habits of mind deemed important to hone talented youth as future STEM leaders and practitioners. Science internships likewise provide an enhanced learning environment to integrate skills and knowledge across different STEM fields.

Through evaluation surveys that used a Likert scale and open ended questions, feedback was gathered on students' experiences and learning in a 2- to 3-week internship in a STEM-focused school in the Philippines. Students' survey responses were coded to arrive at emergent themes, which in turn provided insights on what students learned, and on possible programme enhancements for future implementation.

We report how internships impact student learning and prepare youth for future STEM careers. Some educators (e.g. Bowman, 2014; Cavanagh, 2004; Ismail, 2018; Keegan, 2006) argue that internships benefit both interns and host organisations as student learning and motivation are enhanced, host agency's manpower needs addressed, and industry collaborations established - these are important strategic development goals to support economic growth in a developing country such as the Philippines.

Viewers of this presentation will appreciate how mentor-mentee relationships help develop self-reflection, soft skills, work ethics, creative and critical thinking skills, and collaboration and teamwork among the interns. The presentation will provide insights on STEM-focused schools in the Philippines, talent development in an I-STEM environment, and how to create opportunities to support underprivileged (e.g. girls, economically disadvantaged) students through internship programmes.

13:02 *Janne-Marie Bothor* and *David-Samuel Di Fuccia*

STEM-Hub – Contributions to the Transfer of Science in Educational Contexts

ABSTRACT. An important educational goal is to transfer an adequate understanding of science, its knowledge, its research and its nature into society. The STEM-Hub of the University of Kassel is intended to make an overarching contribution to this. The project focuses on four target groups: Public, Schools, Companies and Science itself. Various educational offers will make research in the STEM field visible and transparent to the „outside world". Measures will also be developed to increase the participants' interest in STEM and to contribute to an improved understanding of science. During the project, the following questions will be evaluated: Do the measures have lasting effects on the participants? Will the interest in STEM be increased and understanding

of science improved? Our poster aims at starting a discussion with international actors in the STEM-Center community by presenting measures already developed as well as the instruments for evaluating the research questions. For example, regarding schools current research content or current research methods are carried out with students in teaching-learning laboratories to help them gaining an insight into the university beyond the school content. To optimize our efforts activities like these shall be networked and expanded within the international STEM center community.

13:10 *Martina Rehnert* and *Ralf Takors*

Science communication in interdisciplinary biotechnology tandem projects to promote STEM-related education and learning.

ABSTRACT. The production of food, pharmaceuticals and chemicals is increasing worldwide. Biotechnology supports an effective and sustainable production demanded by society. Therefore, education and training are needed to successfully train the next generation of biotechnology researchers. However, this is not just about training experts in one field and understanding individual mono-disciplines, but more importantly, an overarching understanding of different disciplines.

An education that combines several STEM disciplines can promote an overall understanding of complexity in general and biotechnology in particular. In biotechnology, the symbiotic fusion of life science and process engineering has been an important aspect since its inception and therefore has a long tradition. In a newly established international network "InterZell", further experience was gained with tandem projects in cross-cutting fields. The established learning community enabled learners, students and researchers to establish supportive relationships with others who share their interest in engineering, technology and life sciences.

The integration of cross-disciplinary practical and methodological skills from engineering and science, is supported by digitization to enriche research and education. Our experience with 50 researchers networked in a priority program over a period of more than 3 years showed that new forms of learning, such as blended learning and edutainment can play a key role in integrating different STEM disciplines in a low-threshold way.

In addition, the experience gained from interaction in different fields was pooled in a learning ecosystem to find new ways in education and training involving cross-disciplinary tandem research and competencies within the network. In particular, the interaction and support of experts from different research fields reveal new ways and concepts and methods for education in a biotechnology network integrating other STEM fields und motivated the learners.

13:18 *Yu-Shan Lin* and *Yao-Chung Chang*

Comprehensive Perspectives on STEM Education in Canada: A Multi-Faceted Exploration

ABSTRACT. The global prominence of Science, Technology, Engineering, and Mathematics (STEM) education is undeniable, with the United States being its originator and Canada, the European Union, and the United Kingdom rapidly adopting and implementing innovative strategies. This study, conducted by visiting scholars in Vancouver, delves into the dynamics of STEM education in Canada across various

sectors, namely universities, K-12 schools, private enterprises, and community initiatives.

At the university level, the study highlights Actua, a network-driven organization representing over 40 Canadian universities and colleges. Actua offers its members training, resources, and support, facilitating STEM education outreach programs tailored for girls, indigenous communities, and youth. Universities also actively engage in routine STEM-related activities, including specialized groups and summer camps featuring STEM courses.

Within K-12 schools, the Vancouver School Board's FuturePLAY program and the Surrey Academy of Innovative Learning (SAIL) stand out. These institutions have strategically designed STEAM programs that emphasize science, technology, engineering, arts, and mathematics and cater to different age groups. The study also explores private sector involvement, exemplified by the Amazon Future Engineer program, which offers coding courses and extends scholarships to high school students.

In the community realm, the study sheds light on initiatives such as the City of Surrey's STEM classes for primary school students, emphasizing the importance of integrating STEM education beyond formal institutions. This comprehensive analysis underscores Canada's proactive stance in promoting STEM education, transcending traditional boundaries. The collaborative efforts of K-12 schools, universities, private industries, and community programs contribute to a robust and accessible STEM education landscape.

The findings suggest that STEM education should not be confined to the classroom but should seamlessly integrate with business and community resources. This holistic approach aims to instill a lifelong learning attitude in students and provide ongoing educational resources. The study's insights are expected to serve as a valuable reference for countries seeking to enhance their approaches to promoting STEM education on a global scale.

13:26 *Sy-Yi Tzeng* and *Chih-Yu Lee*

An Initial Exploration of the Status of the Implementation of Authentic Teaching Elements in the iSTEM Curriculum in Taiwan

ABSTRACT. Background and Objectives: The use of iSTEM (integrated STEM) as a form of education is becoming increasingly important. However, the discussion on STEM education cannot be limited to the integration of subject content. A method for integration of subjects through appropriate design activities to help students address real social and environmental issues is crucial for STEM education in nurturing talent. Authentic teaching elements involve teachers' views on themselves and their teaching, and are closely related to the types of design activities teachers engage in. Therefore, it is important to understand which design activities teachers adopt in their iSTEM curriculum, and which key elements of authentic teaching and learning they put into practice.

Methodology: Based on an instructional design framework for authentic learning environments, six high school teachers who were implementing an iSTEM curriculum in the field in Taiwan were interviewed in this study. These teachers, recommended by 3 STEM education researchers, were interviewed by the authors about the types of

design activities integrated into their curriculum and the key authentic teaching elements incorporated in the design activities they organize.

Results and Applications: The study findings indicate that the key authentic teaching elements practiced by teachers depend on the design activities adopted. For example, the key element of “providing authentic context that reflects the way the knowledge will be used in real-life” requires teachers to allow students to learn from mistakes in the classroom. However, during the “modelling” phase of engineering design activities, teachers often provide specific procedures for thinking and executing instructions before students engage in their creative process, thereby demonstrating the application of knowledge in a limited authentic context. This study offers researchers and educators insights into the challenges teachers may face when implementing authentic teaching in the iSTEM curriculum through design activities, as well as instructional design perspectives on fostering various student abilities to solve real-world problems.

13:34 *Chun-An Lin*, *Chien-Liang Lin*, *Biing-Kun Sheen* and *Tai-Jyi Tseng*

Undergraduate Students’ Technological Cognition, Attitude, Decision, and Risk Perception and Prevention to Information Ethics Issues

ABSTRACT. In the Digital Age, the role of Information Science Education is crucial not only for understanding and applying digital data but also for integrating knowledge across the broad spectrum of Science, Technology, Engineering, and Mathematics (STEM) disciplines. Our study investigates the Information Ethics Literacy of university students, focusing on the impact of technology-driven educational interventions within the broader scope of STEM Education. We employed an online database survey to assess students’ information ethics literacy. And explores six dimensions of Information Ethics: Economic, Social, Educational, Environmental, Health, and Technological. The survey content was informed by an analysis of a decade's worth of digital platform news, with seminar discussions facilitating topic selection. A panel of seven experts, including academics and legal professionals, confirmed the instrument's reliability and validity using a four-point Likert scale. The average weighted score of the question sets was 2.96, and the Content Validity Index (CVI) reached 0.84. Our online survey, conducted with university students, involved comprehensive qualitative and quantitative analyses. Of the 315 questionnaires returned, six open-ended questions underwent qualitative analysis and two rounds of coding, revealing issues related to Privacy Concerns, Procedural Legality, and Risk Perception. In the Healthcare Information Ethics section, students, assuming patient roles, deliberated on whether to disclose medical records under Taiwan’s National Health Insurance System. Their responses prioritized Doctor Competence (68.5%), Privacy Concerns (15.3%), and Self-Interests such as Access (7.7%), Health Benefits (5.6%), and Data Autonomy (2.9%). The analysis led to the categorization of findings into five dimensions: Cognition, Decision, Risk, Risk Perception, and Technology. The Cognition dimension indicated a high level of awareness (average: 2.65), and the Risk dimension showed average perception (average: 0.76, standard deviation: 0.38). The Risk Perception dimension exhibited greater variability (average: 0.64, standard deviation: 0.41). This research underscores the importance of ethical awareness and risk perception in Information Science within the context of STEM Education. It establishes a foundation for future technology-oriented educational endeavors in information ethics literacy, offering insights into students' cognitions and attitudes related to daily Information Science issues and providing valuable reference for curriculum design in Information Science Education.

13:42 *Sheena Ng*, *Cessaline Wang* and *Zhihao Li*
How we 'STEM' at Nan Hua?

ABSTRACT. Nan Hua High School's Science department recognises the importance of integrating STEM education into the school's Science curriculum as it will enable the school to develop 21st century skills in students, preparing them to be critical and creative thinker and problem finders and solvers. The department integrated STEM education through a multi-prong approach. This includes professional development for all science teachers through trainings to level up the competencies of the team to weave in STEM creatively and intentionally into teaching, assessments and STEM-focused PLT projects. To ignite the scientist within our students, all students are provided with opportunities at both Lower and Upper Secondary levels to gain exposure to STEM through platforms such as projects, assessments, challenges, or an enrichment module. From designing and evaluating vertical farming prototypes to building roller coaster models and solar-powered ovens, the department believes that a wide range of exposure will allow the team to inspire students to apply scientific concepts in new situations and develop them into effective communicators about scientific processes. Lastly, the team believes that infusing STEM education into the curriculum can help students understand the role they play in the community by taking on roles of different members of the community (such as industrial roles like marketing manager, engineer, finance manager or members of the Ministry of Sustainability and the Environment). This will enable them to tap on their knowledge to be active contributors towards bettering the lives of those around them.

13:50 *Li Xian Pui*, *Domina Ling Yee Ng* and *Geok Xing Ang*
Unblock the Flow

ABSTRACT. This project seeks to enrich students' understanding of coronary heart disease while integrating STEM concepts, the "Claim Evidence Reasoning" (CER) framework, and peer assessment. Through hands-on experiments, students explore coronary artery occlusion and design techniques to open blocked blood vessels using items provided. This lesson taps on knowledge from other disciplines - in addition to Biology, students need to make use of what they learned in mathematics to propose ways to calculate blood flow rates. Students manipulate tubing to mimic arteries, create blockages on the inner side to represent occlusion, and discuss its consequences. They innovate solutions by coming up with various ways to utilise long balloons to "open up" blocked vessels, employing CER for structured explanations. The project emphasizes collaboration through teamwork, peer assessment and refining their analysis. By merging scientific exploration with structured reasoning, this initiative creates a comprehensive learning experience that nurtures critical thinking and interdisciplinary connections.

14:00-15:30 Session 4A

History, philosophy, epistemology, and nature of STEM and STEM education & STEM curriculum and teaching

CHAIR:
Hendra Tan
LOCATION: 7A-01-07

14:00 *Marcus Clayton*
The teaching of STEM in a moral sphere.

ABSTRACT. This paper attempts to answer questions as to why the spheres of science, technology mathematics and engineering, referred to as STEM, requires an increased sense of ethical prudence. In the current circumstances, the science specialist holds greater moral responsibilities in the face of emerging technologies; artificial intelligence (AI) in particular. The underpinnings of a particular approach to ethics vis-a-vis science is conditional on a brief exploration of a common set of ethical beliefs often present in the science community. I argue as to why the force and inconsistency of these beliefs form controlling elements in how the AI technologist superintends the AI project, and why forms of rule-based governance seem ineffectual. To expand further, I propose measures that can be taken by educationalists to engender a greater ethical awareness in the individual; these include the facilitation of a deeper sense of empathy and a will to act with moral courage. These characteristics, I suggest are to be promoted in the next generation of STEM practitioners as a precursor to better moral responsibility of artificially intelligent systems.

14:30 *Hendra Tan*, *Laudya Sakti*, *Yunika Nugraheni* and *David Nutchey*

Developing Christian character through Indonesian STEM Education

ABSTRACT. The current generation of Indonesian children and youth are challenged by the rapidly changing times. Their mastery of 21st century skills and character formation require more attention and encouragement from educators. In a Christian school environment, if the learning of science and religion is carried out separately it may develop students' perceptions that these two types of knowledge cannot be combined. In fact, the need for scientifically literate students with Christ-like character who can transform social life is really needed in the 21st century. Integrated STEM education is expected to fill the gap that cannot be met by a fragmented, knowledge-based curriculum. This paper discusses a novel integrated STEM subject for grade 11 which is based on the Indonesian national curriculum. Guided by the ADDIE framework, we report upon our progress towards a STEM learning experience that provides space for students' contextualized application of STEM knowledge and which is in line with Christian values, and so be a basis for the students' character formation.

14:00-15:30 Session 4B

STEM curriculum and teaching

CHAIR:
Darren Tan

LOCATION: 7A-01-06

14:00 *Helen Perpetua Onggo* and *Adora Zerrudo*

Development of a Science, Technology, Engineering and Mathematics (STEM) Integrated Curriculum for kindergarten

ABSTRACT. The study is conducted to design and develop a Science, Technology, Engineering and Mathematics (STEM) integrated curriculum for kindergarten. Employing a qualitative meta-synthesis study with focus group discussion and interviews, it examined and drew from studies and early childhood educators the implementation of a STEM-integrated curriculum in kindergarten with focus on STEM as a curricular approach, its pedagogy, learning outcomes, and assessment of learning outcomes. The findings include (a) a common understanding of STEM must be developed among early childhood educators from the Philippines as the first step in

integrating STEM in the kindergarten curriculum; (b) STEM education is an interdisciplinary approach to teaching-learning that purposely explores, finds, and designs meaningful connections between two or more STEM disciplines or between two or more STEM disciplines and other learning areas in the context of a real-world problem; (c) there is no explicit documentation of STEM in the current kindergarten curriculum necessitating the need for the possibilities and initiatives for integrating STEM in the curriculum, (d) STEM education is strongly grounded in constructivism using the pedagogies of inquiry, hands-on, project-based and problem solving, (e) STEM education in kindergarten delivers optimal early learning experiences and leads to positive impact on cognitive skills, self-efficacy, and 21st century skill, and (f) Learning outcomes in STEM education are assessed through non-traditional assessments such as anecdotal evidence and performance tasks. The findings from this study indicate that it is feasible to implement STEM education in the current kindergarten curriculum with several recommendations outlined for future research.

14:30 *Poh Yin Liew*, *Charlene Seah* and *Stephanie Jee*

Curriculum Integration in Science Education in Singapore

ABSTRACT. A benefit of the traditional science curriculum where subjects such as physics, biology and chemistry are taught separately is that this approach allows for systematic instruction of concepts. Whilst some students may see the connections amongst the subjects, the majority of students may not. Being able to see the connections amongst concepts and skills across different subjects will allow a deeper understanding and appreciation of the world around them. The traditional disciplinary approach leaves such connection-making to serendipity.

The problems that we face today such as global warming, climate change, environmental pollution, energy needs are complex and cannot be addressed through the perspective of a single discipline alone. These problems require the perspectives of multiple disciplines, for example, those of Science-Technology-Engineering-Mathematics (STEM), to first of all, gain an understanding of the underlying issues and secondly, to arrive at possible solutions that are well-considered and pose minimal negative impact on Man and his environment. An important desired outcome of STEM is that students are able to draw on the connections across different subjects to address the problems they face now and in the future. In this session, possible approaches of interdisciplinary integration from a review of literature, on incorporating STEM in the Science curriculum will be shared.

STEM can be seen as a special case of interdisciplinary curricula, where subjects are more science centric. Curriculum designers can draw on the research in interdisciplinary curriculum to understand the various extents in which STEM subjects can be integrated. When the extent of integration is expressed explicitly through the resources, teachers will be better supported to implement the curriculum with fidelity. This in turn will develop in students an understanding and appreciation for interdisciplinarity which they could apply to other problems in future.

Approaches for designing meaningful interdisciplinary curriculum units (contextualisation, problem-centring and conceptualisation), STEM lesson as well as considerations for determining the quality of interdisciplinary units will be shared.

The bottom line is that some integration is better than no integration. The integration can be expressed as learning outcomes, built into learning experiences or programmes, and/ or orchestrated through pedagogy.

15:00 *Darren Tan*, *Siew Lin Lee*, *Li Lin*, *Darren Wong* and *Paul Lee*

STEM Pedagogical Content Knowledge for physics teaching and learning

ABSTRACT. This project aims to capture the insights and practitioner knowledge of pre-university teachers in designing and enacting Physics-anchored STEM lessons in Singapore. A 'STEM Portfolio' toolkit was developed, drawing on the concept of pedagogical content knowledge (PCK), as conceptualised through instruments such as CoRes (Content Representation) and PaP-eRs (Pedagogical and Professional-experience Repertoire). The toolkit seeks to elicit and portray teachers' PCK, pedagogical reasoning, and reflections in enacting Physics-anchored STEM lessons designed to develop students' 21st-century competencies.

The 'STEM Portfolio' toolkit was piloted with experienced Physics teachers from three schools which formed a networked learning community to facilitate co-construction of knowledge for their respective STEM lessons. During our presentation, we will share insights on the design considerations for enacting STEM lessons and discuss the toolkit's potential for designing student-centred lessons. We will highlight refinements made to the 'STEM Portfolio' toolkit based on lesson observations, reflections, and interviews with teachers, and provide tips for teachers who wish to develop their knowledge and competencies in STEM teaching. Participants will have a closer examination of teachers' decision-making processes and reflections through vignettes, lesson ideas, and collaborative insights towards fostering effective STEM teaching practices.

14:00-15:30 Session 4C

STEM curriculum evaluation, and assessment

CHAIR:
Mary Sheryl Saldon-Raznee
LOCATION: TR701

14:00 *Kei Kano*, *Takayuki Goto*, *Takayuki Shiose* and *Kaito Wakabayashi*

Development of Cross-Curricular Computer Adaptive Test Assessment of Scientific, Mathematical and Reading Skills and Practice on Its Ethical, Legal and Social Issues

ABSTRACT. Assessment of STEM skills is one of the important issues in STEM education research and practices. We have developed a cross-curricular computer adaptive test (CAT) assessing scientific, mathematical and reading skills. A CAT is an advanced testing system where students' skill level is estimated by their responses, and the most informative problems are subsequently presented to estimate their skills with enhanced accuracy. The CAT is based on the big data of all of the year six (1,066,295) students who participated in national reading, math and science tests in Japan in 2018. Before the development of the CAT, we found that typical science questions in Japan required reading and mathematical skills in addition to scientific skills. This means that science questions are cross-curricular questions. According to the findings, we have developed the CAT, assessing three skills essential for STEM learning simultaneously, mainly using science questions. Then, we introduced the CAT in elementary and junior

high schools in Japan. We succeeded in identifying students who have good scientific and mathematical skills but do not always have good reading skills. Those students are difficult to find in the classic paper tests in Japan because they would not answer scientific questions without proper reading skills. Thus, the cross-curricular CAT, which could assess scientific and mathematical skills independent from reading skills, would be one of the assessment tools for STEM skills. At the same time, in the process of introduction, we realised that considering its ethical, legal and social issues (ELSI) was essential for protecting students' personal data. Moreover, the CAT calculates comparable scores, which could sometimes lead to excessive evaluation. For example, in US, a teacher who was rated "less effective than average" in a teacher evaluation linked to a standardized test committed suicide. Therefore, we found it important to control excessive competition between students, between teachers, and between schools. We also started the project on ELSI of educational technology using student learning data in 2021.

14:30 *Parinya Mutcha* and *Chatree Faikhamta*

Revealing formative assessment to help students improve their learning in STEM activities

ABSTRACT. The goal of formative assessment (FA) is to enhance and advance each student's learning. It has to do with how teachers observe, acknowledge, interpret, and react to what their students are learning. Nevertheless, little is known about the essential components of FA in STEM education activities. This action research is to examine how a science teacher uses FA to enhance students' learning during integrated STEM activities. The participants were forty eleven-year-old students taking chemistry classes. Three types of data were gathered: reflections from teachers, students, and classroom observations. An inductive procedure was utilised to analyse the data. The findings showed that the teacher thought one of the most crucial FA learning objectives was the STEM learning objectives, such as students' scientific explanation. He engaged the students aware of what was expected of them, which helped them see where they fit in. In order to assess the students' thinking, the teacher used evidence that comes up during STEM lessons and questions. After interpreting the evidence, the students were asked to respond thoughtfully. Additionally, classroom discussions aid in students' understanding of their learning path. There is a discussion of how formative assessment can help with other STEM learning objectives.

15:00 *Mary Sheryl Saldon-Raznee* and *Vinesh Chandra*

Examining Student Experiences in an Integrated STEM PBL Initiative at Philippine Science High School

PRESENTER: *Mary Sheryl Saldon-Raznee*

ABSTRACT. Philippine Science High School (PSHS) launched its integrated STEM project based learning (PBL) initiative called Kids' Innovation Program (KIP), a co-curricular activity that incorporates design thinking and engineering design approaches in solving real world problems. In the recently concluded KIP, in collaboration with its partner, UNICEF-Water Sanitation and Hygiene (WASH) Unit, year 10 and year 11 students produced portable household toilet designs and rainwater collection kiosks with filtration system using sustainable construction materials. These designs with their blueprints will then be used to construct prototypes in impoverished and disaster hit areas in the Philippines. Despite its success over the years, the KIP has encountered implementation challenges particularly financial resources and time commitment from students and teachers. Students are already occupied with the rigorous curricular

requirements, while teachers are already engrossed with both teaching and non-teaching tasks. Thus this study aims to document and assess the impact, efficiency, and efficacy of this co-curricular STEM PBL program, and to examine the possible incorporation of the program to the curriculum of years 11 and 12 as a compulsory course. Incorporating the KIP as a STEM course would circumvent the current challenges faced being a co-curricular program. Furthermore, the results of this study would also provide the groundwork for an integrated STEM curriculum that would benefit all PSHS students. For data gathering, an evaluation survey based on Kirkpatrick's Model, focal group discussions (FGDs) and key informant interviews will be conducted with students (and mentors) that have experienced the KIP, especially the recently concluded KIP-UNICEF. However, for both qualitative and quantitative data of the evaluation, students who did not get to participate in the KIP will be included in the survey as well. The outcome of this study will inform plans for the incorporation of co-curricular or curricular integrated STEM activities that are anticipated to enhance the school's STEM curriculum.

14:00-15:30 Session 4D

STEM education goals and policy

CHAIR:
Tomotaka Kuroda
LOCATION: TR702

14:00 *Yu Jiang*, *Yang Liu* and *Jianzhong Zhou*

Policy research on the guarantee mechanism of science education in China

ABSTRACT. The crisis brought about by the novel coronavirus has accelerated the development of the fourth Industrial Revolution, but also made people realize the importance of emerging technologies for the future development of the world. The great changes in production organization and productivity brought about by emerging technologies put forward new requirements for the future industrial structure and labor literacy. Science education is the fundamental guarantee to effectively improve the quality of science and technology and culture of citizens, to train high-quality workers and scientific and technological innovation talents. As a guarantee for the development of science education, the guarantee mechanism of science education is a set of elements to guarantee the smooth development of science education. This study deeply analyzes the development status of the guarantee mechanism of science education in China, such as the policy system, financial investment and multi-subject collaboration. It is found that the existing problems of the relevant mechanism include the lack of fund allocation system, the large gap of equipment and facilities, and the poor situation of science education curriculum. Especially in the interaction mechanism between science and technology innovation and science education, the coordination mechanism of multi-agent participation in science education has not been established, and the participation of science and technology resources and social resources in science education is insufficient. Based on this, this study puts forward policy suggestions such as formulating education development strategy for the future development of the country, building a multi-input guarantee mechanism, giving full play to the synergies of government departments, education systems, research institutions, enterprises and venues, and deepening the integration of science and education to promote talent training models.

14:30 *Divya Chandrasenan* and *Reshma John Kuleenan*

Shaping Tomorrow: Assessing the Landscape of STEM Education for Girls in India

ABSTRACT. The gender digital divide, hurdles, negative perceptions, and gender conventions prevent girls from reaching their full potential. Lack of role models, restricted opportunities, and expectations for women performance in STEM pose serious obstacles to girls' ability to acquire the necessary skills. In spite of the various programmes by the government of India to tackle gender disparity, a significant percentage of adolescent girls drop out of training and education each year due to gender socialisation and norms, which causes them to have lower self-efficacy and perceptions of their own abilities. These girls also fail to acquire skills like entrepreneurship, problem solving, and innovative and critical thinking, which are necessary for success in jobs of the twenty-first century. The present project tries to assess the current programmes on STEM skills among adolescent girls and to find the gaps and opportunities in skills for girls in science careers. To assess their participation and performance in the domain, identify needs and gaps, and suggest possible ways forward, the project team has administered three activities. (A) Country profiling based on the review and analysis of secondary (both qualitative and quantitative) data. (B) A written survey was organized and disseminated across the 14 districts of Kerala, India. The questionnaire had 20 questions formulated to identify existing initiatives and explore characteristics of skills for girls´ programmes ongoing or in the pipeline. (C) Discussions were organized to include points of reflection and input to the mapping process and ensure that key perspectives were considered. Based on the findings of these activities, observations were noted as responses to the research questions. Further, gaps in the review were identified, and a set of recommendations, including the preparation of Innovative Gender-responsive STEM pedagogy were formulated.

15:00 *Tomotaka Kuroda*, *Chanyah Dahsah* and *Chatree Faikhamta*

Study on the Extraction and Recognition of Competency Models of the STEM Human Resources Community: Focus on Gender of Higher Education Students in Thailand

PRESENTER: *Tomotaka Kuroda*

ABSTRACT. The development of human resources in the fields of STEM denotes a crucial component of national advancement. Such human resource competencies are actively sought worldwide by promoting STEM and STEAM education. Such attempts span from the K-12 to the university levels. Diverse applications are frequently offered at varied developmental stages based on specific cultural contexts. Interpretations of STEM and STEAM education policies and activities exist in Thailand; for instance, the STEM Bio-Circular-Green economy model, STEAM4Innovation, and the STEM2 model are conducted in local contexts. Other policies and practices are also implemented by international organizations and several government agencies that endeavor actively to strengthen STEM education and human resource development as an aspect of national policy. Cultural backgrounds influence competency models, including examples of 21st-century skills. However, we need to understand what specific attributes can be identified when the characteristics of the STEM human resources (HR) community are considered in light of cultural features. This study surveyed undergraduate and graduate university students majoring in STEM fields in Thailand. The survey focused on their perception of a skill set comprising 21 competency elements. The results showed significant differences in five items for self-assessment and 16 items for motivation for future learning, and very weak significant

differences in only one item (Information, Media, and Technology Literacy) for the competence component required for STEM HR, confirming that this item is particularly, was strongly influenced by cultural and social influences. Therefore, Thailand students have very few gender differences in the STEM HR community and the images that lead to the required competencies. Future studies could expand the scope of our studies to include high school students and working individuals, which will allow a more intensive exploration of the impact of Thailand's educational curricula and cultural characteristics on the development of STEM human resources.

14:00-15:30 Session 4E

STEM learners and learning

CHAIR:
Min Zhong

LOCATION: TR703

14:00 *Koo Li Kheang*, *Lim Xinjie*, *Lee Seng Lee* and *Ong Sze Ying*

A study of STEM learning experiences for secondary school students in their collaboration to design a solution to resolve an authentic problem during an overseas learning journey

ABSTRACT. STEM curriculum typically takes place within local school contexts such as classrooms or informal learning spaces. However, students' STEM learning experiences can be broadened by taking part in overseas learning journeys that provide STEM learning experiences beyond borders. To this end, Cedar Girls' Secondary School in Singapore collaborated with a school in Vietnam to implement intercontextual STEM learning experiences for a learning journey in November 2023. It is envisaged that the creation of an authentic problem that resonates with students from both economies would facilitate this collaboration.

An inquiry task based on the S-T-E-M Quartet instructional framework (Tan, AL., Teo, T.W., Choy, B.H. et al. The S-T-E-M Quartet. Innov Educ 1, 3 (2019) was designed and students were asked to act as researchers tasked to solve a food security problem that is based on the United Nations Sustainable Development Goal of Zero Hunger (Goal 2).

The research questions that will be addressed are: (1) How do Singaporean and Vietnamese students interpret the problem of food security? (2) How do they approach this problem in their STEM inquiry task?

A mixed group setting comprising students from both schools will be adopted to allow them to collaborate and propose an innovative solution to produce or distribute locally produced food in a sustainable way. Online meetings and a hackathon will enable students to discuss and build a prototype to showcase their solution based on the Vietnamese context. The solution will then be presented to stakeholders to obtain feedback. Post hackathon, the relevance of the prototype in the Singapore context was discussed to tweak the solution.

Data collected during the learning journey will be analysed using qualitative coding methods to address the two research questions mentioned above. The data will include student surveys, interviews, and student artefacts, such as reflections and presentations.

Photographic evidence of prototypes taken at the hackathon was collected as data to assess dispositions and aptitudes. It is hoped that this multi-disciplinary task will provide an example for the planning of future learning journeys for educators that have the same aim in mind.

14:30 *Pongprapan Pongsophon*

Middle School Thai students' perspectives on computational thinking practices through programming with the micro:bit

ABSTRACT. The purpose of this study is to investigate middle school Thai students' perceptions of computational thinking (CT) practices through collaborative programming with the micro:bit. The students attended the Coding Camp for Helping People with Special Needs, where they were first introduced to the principles of the Internet of Things (IoT), programming, and micro:bit device characteristics before being instructed on how to code with the micro:bit in a text programming environment. They worked as a group to explore and propose solutions to difficulties that persons with special needs face. They were asked to illustrate how the proposed solution would be implemented using micro:bit programming. They used the micro:bit to prototype the idea and solicited input from their colleagues to validate it. Finally, each team gave a business pitch about their items. Following the camp, each team participated in a focus group interview to discuss their perceptions about computational thinking practices, the obstacles they faced when implementing their ideas using the micro:bit, and the practices and approaches they utilized to overcome such challenges. It discovered that the most difficult sorts of CT practices to implement were algorithms, code debugging, and collaboration. The activities that the participants thought would help them overcome the problems were receiving immediate and constructive feedback from the teachers and building a collaborative and supportive culture in a classroom.

15:00 *Min Zhong*, *Teng Zhao*, *Scott Bowling*, *Ruth Buskirk* and *John Willford*

Unpacking Metacognition in STEM Learning: A Comprehensive Study with Embedded Intervention

ABSTRACT. Background and Objectives The field of STEM education faces ongoing challenges in enabling students to transfer and apply learned concepts to various contexts. Metacognitive strategies have been widely promoted in disciplinary teaching practices to foster students' self-regulatory skills. However, differences in the effectiveness of implementing metacognitive intervention have been observed across student levels and class performance. Considering the challenges and in line with the Conference Strand of STEM Learners and Learning, this study aims to address two key objectives: 1) understanding the variations in metacognitive awareness among students across different class levels, genders, ethnicities, STEM disciplines, and its correlation with students’ goal orientations. 2) examining the influence of embedded metacognitive interventions in freshman-level introductory biology courses on undergraduate students' acquisition of STEM content.

Methodology To assess students' level of metacognition, we administered the Metacognitive Awareness Inventory (MAI) at the beginning and end of the semester in multiple STEM classrooms and then collected data from the intervention classroom of the metacognition-embedded introductory biology classes across multiple institutions in the other semester.

Results and Discussion The findings indicate that overall metacognitive awareness does not naturally grow significantly in all students, suggesting the need for metacognitive interventions. Notably, discipline and content learning emerge as factors leading to the significant difference in developing metacognitive skill development among students at similar levels. Moreover, both mastery approach and performance approach goal orientations exhibit positive relations with all categories of metacognitive awareness. This highlights the importance of guiding students toward cultivating positive learning behaviors through goal orientation.

Furthermore, our results from the embedded metacognitive intervention demonstrate a positive association between improvements in students' metacognition and higher academic achievement. Therefore, this study comprehensively underscores the importance of incorporating metacognitive interventions into STEM education to enhance students' learning outcomes.

Through exploring the variations in metacognitive awareness, investigating the impact of embedded interventions, and analyzing the correlation between metacognitive skills and goal orientations, this study contributes to our understanding of how to enhance student learning in STEM classrooms.

14:00-15:30 Session 4F

STEM teacher and teacher education

CHAIR:
Alfons Jayson Pelgone
LOCATION: TR704

14:00 *Chanakan Thananiwat* and *Sasithep Pitiporntapin*

Demonstration School Teachers' Need for Developing Outdoor STEM Teaching Practices

ABSTRACT. This research aimed to 1) investigate the requirements of demonstration school teachers regarding teaching practices in outdoor STEM education, and 2) analyze the root causes of issues as well as potential solutions to support these teachers in developing their outdoor STEM education teaching methods. The study involved 40 teachers who participated in an online questionnaire designed to assess their needs for improving outdoor STEM education teaching practices. Data was collected through an open questionnaire, soliciting information about teaching experiences related to STEM outdoor learning and ideas for implementing outdoor learning in STEM education. The researchers utilized the modified Priority Needs Index (PNImodified), means, standard deviations (SD), and content analysis. The results indicated that the foremost need to enhance demonstration school teachers' outdoor STEM education teaching practices was providing opportunities for students to explore the environment as a learning resource, enabling them to develop problem-solving skills beyond the classroom setting (PNImodified = .67). Commonly identified challenges by demonstration school teachers included limited access to outdoor resources and a lack of real-world context, particularly the difficulty in connecting STEM concepts to real-world situations and the challenge of integrating knowledge from various areas into STEM activities. To address these challenges, it is crucial for teachers to be able to create or incorporate activities using local resources. Implementing teacher training programs, such as workshops, professional learning communities, and ongoing professional development

opportunities, is essential to equip teachers with the necessary skills and confidence for effective integration of outdoor STEM education.

14:30 *Lynn Bryan*

Supporting Teacher Learning for Designing K-12 Integrated STEM Instruction: An Integrated STEM Education Certificate Program

ABSTRACT. The integration of STEM disciplines is complex and requires that teachers have a robust understanding of not only the content and practices of each of the integrated disciplines but also the alignment and coherence among integrated STEM teaching approaches, learning goals, and assessments (NAE/NRC, 2014; Wang, Moore, Roehrig, & Park, 2011). However, understanding culture, practices, and ways of knowing and sharing knowledge of the STEM disciplines constitutes only part of the path to integration. One of the key challenges in designing integrated STEM instruction is connecting core content knowledge and processes across the disciplines (English, 2015). Teachers are called to design opportunities to engage students in discipline-specific practices, while at the same time recognizing and understanding how the individual disciplinary knowledge, skills, and practices support and inform each other. In response to this challenge and with the 2013 release of the Next Generation Science Standards (NGSS Lead States, 2013) calling for the integration of engineering design content and practices into science instruction, faculty in the Center for Advancing the Teaching and Learning of STEM (CATALYST) at Purdue University designed a K-12 Integrated STEM Education Certificate Program that emphasizes the development of teacher knowledge for connecting core content knowledge and processes across the discipline in ways that are socially relevant and culturally inclusive and who, in turn, will prepare their students to solve problems, understand technology, value cultural diversity, and work effectively in interdisciplinary teams. In this session, we will (1) articulate the conceptual framework guiding our development of the K-12 Integrated STEM Education Certificate Program; (2) share the learning goals of the program and the series of courses that address these learning goals; (3) present evaluation data and research emanating from the program; and (4) reflect on the successes, challenges, and lessons learned after 10 years of implementation of the K-12 Integrated STEM Education Certificate Program. This work has implications for STEM teacher educators who design learning experiences for teachers to build pedagogical approaches for integrating STEM instruction that are culturally responsive, respectful, and effective and reflect an understanding of sociocultural processes and discourse practices of learning.

15:00 *Alfons Jayson Pelgone* and *Marie Paz Morales*

Insights of STEM Professionals in Developing a STEAM Teacher Preparation in Society 5.0

ABSTRACT. Society 5.0 conceptually places humans and their activities at the center of technology- and data-transformation. In this society, people must utilize their creativity and the available technology to solve pressing concerns and invest in quality lives. Literature on Society 5.0 and national policy directions like the Pagtanaw 2050 highlight the role of STEAM education on talent development for STEM jobs and research and development initiatives. Therefore, it is imperative to envision the development of a STEAM teacher preparation aligned with Society 5.0 in the Philippines. The study employed an exploratory research design and a focus group discussion (FGD) as data collection procedure. In this study, fifteen (15) Filipino scientists and STEM professionals (SSP), employed locally and internationally, were

purposefully selected because of their education, research, and industry experience and expertise. Through the FGD, the SSP shared their insights about STEAM education and teacher preparation. Through a validated FGD protocol, the data were transcribed, analyzed, coded, and underwent abstraction to generate codes and categories. The emerging categories were used to clarify and explain the STEM professionals' collective insights and visions regarding STEAM teacher preparation for Society 5.0. The data analysis process shows that the scientists have varying degrees of agreement on the nature of a contextualized Society 5.0 in the Philippines, the need for STEAM education and teachers, the drivers, what constitutes a STEAM teacher preparation and its outcomes, and enablers and challenges. The FGD data has elaborated that Filipino scientists support the vision of a Filipino Society 5.0 that promotes equal access to efficient government services, technology, and human talent development. They further defined the nature of the STEAM teacher outcomes in terms of functions such as research, instruction, leadership, and competencies that allow them to think creatively and critically, interact with others, and stay relevant. These outcomes would be realized through a robust STEAM teacher preparation curriculum characterized by depth of content, flexible curriculum delivery, interdisciplinary content, and collaborations with industry partners. The results of this study indicate the need for continuous curricular recalibrations in teacher education as a response to societal evolutions and disruptions such as Society 5.0.

14:00-15:30 Session 4G: Workshop by Duck Learning

Workshop: AI Explorers: Journey into Education's Future!

Presenter(s): Ali Asghar and Joel Heng

Synopsis:

In our upcoming workshop, we will embark on an enlightening journey into the realm of Artificial Intelligence (AI) and its integration into education, using the revolutionary platform PictoBlox. PictoBlox is a block-based and Python programming platform designed for kids and teens, offering a creative and engaging approach to learning coding. With PictoBlox, students are empowered to explore various domains of 21st-century learning, including AI, Machine Learning, Robotics, and Game Designing, fostering a generation of tech-savvy innovators ready to tackle the challenges of the digital age. During the workshop's first segment, educators will delve into the fascinating world of Computer Vision, learning how to create their own Machine Learning models capable of identifying different objects. Through hands-on exploration, teachers will gain insights into the practical applications of Machine Learning, from driving autonomous cars to detecting cancer cells, illuminating the myriad possibilities of this transformative technology.

In the second segment, educators will apply their newfound knowledge to create Machine Learning models for a specific task: identifying different types of flowers. Aligned with science curriculum objectives, this activity enables teachers to delve into the intricacies of flower anatomy, life cycles, and

ecological roles. By "training" their Machine Learning models to recognize and describe various flowers, educators not only enhance their understanding of AI but also gain practical insights into integrating technology into interdisciplinary learning experiences.

In conclusion, the workshop underscores the importance of innovative pedagogical approaches such as the QUACK methodology in harnessing the power of technology for educational purposes. By prioritizing maximum engagement and "learning through play," QUACK empowers educators to create immersive and meaningful learning experiences that resonate with students. Through the integration of PictoBlox and AI, educators are equipped with the tools necessary to cultivate a generation of critical thinkers, problem solvers, and digital innovators poised to thrive in the digital age and beyond. Join us as we embark on a transformative journey towards inspiring the next generation of AI enthusiasts and tech leaders.

LOCATION: TR705

15:30-17:00 Keynote 4: Lyn D. English

Ways of Thinking in STEM-based Problem Solving

This presentation will argue that traditional notions of problem solving are outmoded, highlighting the need for more future-oriented approaches. Compelling evidence for reviewing and restructuring school problem-solving experiences can be found in the ill-conceived ways in which society dealt with Covid-19. A focus on ways of thinking in dealing with unforeseen problems has been lacking in education, despite an OECD report warning 13 years ago that “Education today is much more about ways of thinking which involve creative and critical approaches to problem-solving and decision-making.” The presentation will address this gap by examining various modes of thinking with-in STEM-based problem solving across the primary and middle grades. Consideration will be given to design and design-based thinking, systems thinking in dealing with complexity, critical and philosophical thinking, and adaptive and innovative thinking. In conjunction with fostering disciplinary and interdisciplinary concept development, ways of thinking can promote students’ competence in undertaking STEM-based investigations. Design-based thinking, for example, is increasingly prevalent in STEM and in society more broadly. Appropriate problem experiences can facilitate students’ learning about design and through design, with the former targeting the iterative processes of designing, and the latter, STEM knowledge application and development. Examples of investigations encouraging different ways of thinking across primary and middle grades will be explored, covering topics in mathematics education and STEM education more broadly, such as, mathematical representations, models and modelling,

scheduling, measurement and geometry, spatial reasoning, coordinates, statistics, and earth science including energy sources.

LOCATION: LT1

17:00-17:30 Closing Ceremony

LOCATION: LT1

Keynotes

Venue: LT1

Keynote 1 **Prof Gillian ROEHRIG**	Gender Equity Related to Integrated STEM in K-12 Classrooms Moderator: Ast/P Ban Heng CHOY	Day 2 1000 - 1130
Keynote 2 **Prof Jinwoong SOONG**	Separately and Together: The Dilemmas of STEM Education Moderator: A/P TAN Kim Chwee Daniel	Day 3 0900 - 1030
Keynote 3 **Ast/P CHOY Ban Heng**	Noticing Affordances for Developing Integrated STEM Mindsets through "Day-to-Day Classroom" Mathematics Tasks Moderator: Ast/P ONG Yann Shiou	Day 3 1100 - 1230
Keynote 4 **Prof Lyn D. ENGLISH**	Ways of Thinking in STEM-based Problem Solving Moderator: A/P LEE Yew Jin	Day 3 1530 - 1700

Keynote 1 Day 2, 1000 - 1130

Gillian Roehrig

Professor of STEM Education
University of Minnesota, USA

Dr. Roehrig is a professor of STEM Education at the University of Minnesota. Her research explores issues of professional development for K-12 science teachers, with a focus on implementation of integrated STEM learning environments and induction and mentoring of beginning secondary science teachers. Her work in integrated STEM explores teachers' conceptions and implementation of STEM, curriculum development, and student learning in small groups during STEM lessons. She has received over $50 million in federal and state grants and published over 120 peer-reviewed journal articles and book chapters. She is a former president of the Association for Science Teacher Education and the Immediate Past President of NARST.

Gender Equity Related to Integrated STEM in K-12 Classrooms

Recent educational reforms in the United States promote integrated science, technology, engineering, and mathematics (STEM) as a means of remaining globally competitive and advancing the knowledge and thinking skills of all students (National Research Council, 2012). However, despite efforts to improve access and quality of STEM education, women continue to be underrepresented in STEM fields (National Science Foundation, 2017). Given the prevalence of small group activities in K-12 STEM instruction, it is important to understand how students engage in epistemic discourse as they develop design solutions to real-world problems and engage in authentic STEM practices, parallel to those of STEM professionals. Given issues with gender equity in STEM, it is particularly important to consider the engagement of girls in STEM discourse and the impact on their developing STEM identities.

Keynote 2 Day 3, 0900 - 1030

Jinwoong Soong

Professor of Physics Education
Seoul National University, South Korea

Jinwoong Song is a professor of physics education at Seoul National University (SNU), the director of SNU Teacher Education Innovation Center (TEIC), and a fellow of the Korean Academy of Science and Technology (KAST). He received his BSc in physics and MEd in science education from SNU, and his PhD in science education from King's College London in 1990. He has been actively engaged with international collaborations for establishing EASE (East-Asian Association for Science Education) as its 2nd president and APSE (Asia-Pacific Science Education) journal as its 1st editor-in-chief. Along with his life-long work with Korean Association for Science Education (KASE), he has served for several national-level policy making for the innovations of Korean science education, including Science Core Schools, 2015 National Science Curriculum, and Korean Science Education Standards (KSES). With ongoing academic interests in the interplay between science education and HPS (the history and philosophy of science), his current research interests cover science curriculum, the nature of science / physics, East Asian science classroom culture, science classroom creativity, science as wisdom, and the history and philosophy of science education.

Separately and Together: The Dilemmas of STEM Education

Today, STEM education has become an irreversible global trend. It has become a 'slogan' for reforming current school and university education in both so-called developed and developing countries. STEM education is similar to the STS education of the 1980s and 1990s in that it emphasizes its integrated approaches and social contexts, but is different in that its core subjects go beyond science to include mathematics and engineering. In addition, the dilemmas surrounding the nature and methods of STEM education still continue. The first dilemma is whether the focus of STEM education should be on expanding its scope in curriculum or reforming its essential methods in teaching. The second dilemma is that mathematics, science, and engineering, the components of STEM, have not only common features but also significant differences in their natures. If we emphasize the common features, it is easy to miss the nature of individual disciplines, and vice versa. The third dilemma is that the nature of each individual discipline itself has been fundamentally changing through the second half of the 20th century. What STEM educators think of as their respective fields of study is no longer consistent with that of the 21st century. In this presentation, I will look back on the historical developments of emphasizing the social relevance of science in school education, compare the features of STEM disciplines, and explore its practical future direction by focusing on the 'participation and action' dimension of STEM education.

Keynote 3 Day 3, 1100 - 1230

Choy Ban Heng

Assistant Professor in Mathematics Education
National Institute of Education
Nanyang Technological University, Singapore

Dr. Choy Ban Heng is an Assistant Professor in Mathematics Education at the National Institute of Education, Nanyang Technological University, Singapore. As a recipient of the NIE Overseas Graduate Scholarship, Dr. Choy received his PhD from the University of Auckland, New Zealand, in 2015. He is currently one of the co-Heads for meriSTEM@NIE, a Multi-centric Education, Research, and Industry STEM centre in NIE. As a mathematics educator, Dr. Choy's research focuses on developing mathematics teachers' expertise in noticing critical mathematical and instructional details during the planning, enactment, and review of lessons. His other research interests include teacher professional learning, mathematics instructional practices, mathematics task design, and more recently STEM education. He currently serves as an Associate Editor of a new STEM education journal published by Brill. Besides being the principal and co-principal investigators of several research projects, Dr. Choy was also the leader for a STEM teacher development project in Thailand funded by Temasek Foundation.

Noticing Affordances for Developing Integrated STEM Mindsets through "Day-to-Day Classroom" Mathematics Tasks

There have been calls for Science, Technology, Engineering, and Mathematics (STEM) educators to design learning experiences around authentic integrated STEM tasks—those that involve two or more disciplines—to empower our learners to develop productive mindsets or habits of mind necessary for navigating through a highly complex and uncertain world. Much of our efforts revolves around designing integrated STEM tasks that centre around solving a complex persistent problem, developing and enhancing existing solutions, or designing for specific users in different contexts. Designing and implementing such integrated STEM tasks poses several challenges for teachers and such approaches often engender a polarising discourse between integrated STEM tasks and "day-to-day classroom" tasks. This gap between integrated STEM tasks and "day-to-day classroom" tasks is even more evident in mathematics classrooms. With the aim of developing productive integrated STEM mindsets, I wonder if we can challenge this limiting thinking and re-envision how affordances of "day-to-day classroom" mathematics tasks can be harnessed differently. In this presentation, I will add to this ongoing conversation by considering and illustrating how these "day-to-day classroom" mathematics tasks can complement integrated STEM tasks to make STEM learning an integral part of everyday mathematics learning experiences.

Keynote 4 Day 3, 1530 - 1700

Lyn D. English

Professor of STEM Education/Mathematics Education
School of Teacher Education and Leadership
Queensland University of Technology, Australia

Lyn English is Professor of mathematics education and STEM education at the Queensland University of Technology, Australia. Her areas of research include mathematics/STEM education, ways of thinking in integrated STEM-based problem solving, mathematical modelling, engineering education, and statistical reasoning. Her research has been supported for many years by grants from the Australian Research Council. Professor English is a Fellow of The Academy of the Social Sciences in Australia, and is founding editor (1997) of the international journal, Mathematical Thinking and Learning (Taylor & Francis). She was awarded the Mathematics Education Research Group of Australasia Career Research Medal in 2012, and the University Vice Chancellor's Award for Excellence in Research in 2015.

Ways of Thinking in STEM-based Problem Solving

This presentation will argue that traditional notions of problem solving are outmoded, highlighting the need for more future-oriented approaches. Compelling evidence for reviewing and restructuring school problem-solving experiences can be found in the ill-conceived ways in which society dealt with Covid-19. A focus on ways of thinking in dealing with unforeseen problems has been lacking in education, despite an OECD report warning 13 years ago that "Education today is much more about ways of thinking which involve creative and critical approaches to problem-solving and decision-making." The presentation will address this gap by examining various modes of thinking with-in STEM-based problem solving across the primary and middle grades. Consideration will be given to design and design-based thinking, systems thinking in dealing with complexity, critical and philosophical thinking, and adaptive and innovative thinking. In conjunction with fostering disciplinary and interdisciplinary concept development, ways of thinking can promote students' competence in undertaking STEM-based investigations. Design-based thinking, for example, is increasingly prevalent in STEM and in society more broadly. Appropriate problem experiences can facilitate students' learning about design and through design, with the former targeting the iterative processes of designing, and the latter, STEM knowledge application and development. Examples of investigations encouraging different ways of thinking across primary and middle grades will be explored, covering topics in mathematics education and STEM education more broadly, such as, mathematical representations, models and modelling, scheduling, measurement and geometry, spatial reasoning, coordinates, statistics, and earth science including energy sources.

Tradeshow Highlights

Venue: Outside LT1

Opening Hours: Day 2 and Day 3 @ 0900-1730

S/N	Organisation / Company	Description
1	**Springer**	Springer is part of Springer Nature, a leading global publisher that serves and supports the research community. With one of the strongest HSS and STM eBook collections and archives, Springer has a comprehensive range of authoritative books, journals, and reference works covering key areas in their respective fields. We are exhibiting at the ISEC and ISTEM-ED conferences, and invite you to explore our growing portfolio and find out more about the benefits of publishing with Springer. Researchers interested in authoring or editing a book are encouraged to drop by and have a chat with our Publishing Editors. https://www.springer.com/gp
2	**BERNINA Education**	BERNINA Education has been developed for learners and educators to acquire a unique blend of digital and soft skills, essential for 21st-century education. Our programmes are proven to promote and develop patience, resilience and improve overall mental well-being. We aim to inspire and empower individuals by instilling creativity, design thinking, hands-on problem-solving skills and collaboration through our innovative, engaging and interactive programmes. We champion holistic education in equipping a new generation of learners and creators. We offer a range of Education Programmes (for Primary, Secondary, Tertiary Levels & Institutes of Higher Learning) that focus on Sustainability, Innovation, Prototyping and Creativity. https://bernina.com.sg/
3	**DOST Science Education Institute**	Science Education Institute is one of the attached agencies of the Department of Science and Technology (DOST). It is mandated to develop the Philippines' human resource capacity in science and technology through administration of undergraduate and graduate scholarships and advanced specialized trainings, conduct of promotional and research activities in Science and Technology, and development of innovative science education programs. The Innovations Unit (IU) of the SEI - Science Education and Innovations Division (SEID) meanwhile develops and produce educational resources, models and strategies to support teaching and learning of science and mathematics from pre-school to Grade

S/N	Organisation / Company	Description
		12 through prints, digital, interactive and immersive technology 4platforms. https://sei.dost.gov.ph
4	**Duck Learning**	Established in 2007, Duck Learning has emerged as a trailblazer in the field of STEAM education, driven by a deep-seated commitment to empowering students and educators alike. Duck Learning ignites a passion for STEAM (science, technology, engineering, arts, math) by offering exclusive educational resources. As the distributor for LEGO Education, Quarky by STEMpedia, KUBO robotics, Databot, and Strawbees, they provide innovative kits, tools, and curriculums. These resources seamlessly integrate Robotics and AI into classrooms. Duck Learning's "The QUACK Methodology" fosters self-directed learning and cultivates essential 21st-century skills like critical thinking, collaboration, communication, and creativity. https://ducklearning.com/
5	**LD Didactic GmbH**	From the beginning in 1850 till now, LD DIDACTIC concentrates on how to make content understandable for students in different levels of scientific and technical STEM education. So we are proud that for generations our training systems have made a significant contribution to knowledge transfer. We have found that you can achieve a lot when keeping up with customer's needs: we continuously challenge ourselves to preserve our high-quality standards and adjust our products and services to changing curricula or new technologies. We can supply all from one source: Teaching systems, software for experiments and organization, experiment literature and teacher training. https://www.ld-didactic.com/
6	**NIE Graduate Studies and Professional Learning**	The National Institute of Education offers evidence-informed graduate, executive leadership and professional development programmes and courses for educators and professionals in educational settings. Our faculty members are deeply passionate about teaching and learning. They are experts in education, and many are also internationally renowned in their respective academic fields. Our aim is for students and learners to become thought leaders, skilful teachers, disciplinary experts and good researchers. This aspiration is embodied in our philosophical statement of "Learning Differently, Leading Change".

S/N	Organisation / Company	Description
		https://www.ntu.edu.sg/nie/about-us/programme-offices/office-of-graduate-studies-and-professional-learning
7	**Science Centre Singapore**	At Science Centre Singapore, we make science accessible and engaging, creating an environment that fosters a love for science and discovery in all who visit. With 14 exhibition galleries, we house more than 1,000 exhibits covering a wide range of topics related to science, technology, engineering and mathematics (STEM). We also offer a wide range of enrichment programmes for students, professional learning activities for educators, as well as enriching and fun events, competitions and outreach activities for people from all walks of life. Join us at the Science Centre, as well as other Science Centre attractions such as Omni-Theatre, Snow City and KidsSTOP. https://www.science.edu.sg/
8	**Spectra-Teknik (S) Pte Ltd**	Spectra-Teknik (S) Pte Ltd is a Singapore-based company and we specialize in supplying Scientific Equipment suitable for Laboratory, Out-Field and Industrial use. Given our broad product offering, we have a wide clientele base in various fields, including but not limited to Government Agencies, Universities, Research and Educational Institutions/Schools as well as Industries in Semi-Conductors, Petro-Chemicals, Pharmaceutical and Food. https://spectra-teknik.com/
9	**Stick'Em Pte Ltd**	Our mission is to give every child an avenue to pursue quality STEAM Education and create thinkers and problem-solvers for the future of humanity. Nearly 1 billion children are growing up without proper technological education. In 2030, without STEAM skills, most of these children won't have a future. Our solution? SUPER affordable STEAM Kits to empower children to develop curiosity in STEAM fields, paired with our Stick 'Em online ecosystem that engages students in fun and exciting STEAM challenges. https://stickem.sg/
10	**Texas Instruments**	For more than 30 years, Texas Instruments (TI) has been an active member of classrooms around the world, empowering teachers and inspiring students to succeed in mathematics and science. Through our calculators, coaching and classroom resources, TI

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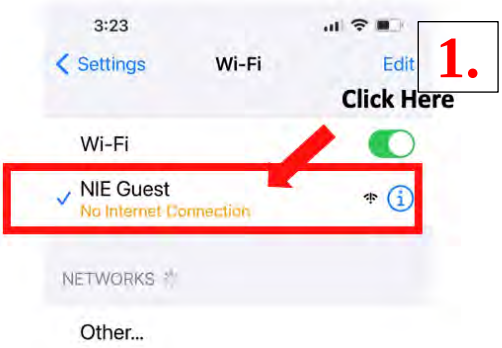
		Education Technology is transforming the way teachers teach and students learn STEM (science, technology, engineering and mathematics) subjects. With our award-winning products, engaging lessons, real-time assessment and top-notch professional development, TI is leading the way in mathematics and science education. https://education.ti.com/
11	**Tinker Class Pte Ltd**	Tinker Class delivers comprehensive technology education solutions tailored for schools, educators, and learners across Singapore and Southeast Asia. Our extensive selection of STEM products is perfect for makerspaces and classrooms alike, featuring popular brands like micro:bit, Raspberry Pi, M5Stack, Gigo Toys, 3Doodler, ElecFreaks, Chibitronics, Makedo, Cubetto, Sphero, and more. As STEM educators ourselves, we regularly incorporate these products into our own classes, giving us in-depth knowledge of the curated catalogue we offer. https://tinkerclass.tech/
12	**VEX Robotics**	VEX Robotics is educational robotics for everyone. The VEX Continuum spans all levels of both formal and informal education from primary though to university education. With accessible, scalable, and affordable solutions, VEX encourages science and engineering principles as well as creativity, teamwork, leadership, and problem solving among groups. It allows educators of all types to engage and inspire the STEM problem solvers of tomorrow! VEX offers robotics solutions and lesson plans for classroom use, robotics competitions for extra-curricular use and ongoing professional development through our PD+ platform. https://vm-education.com/vex-robotics/

Internet Access

Complimentary Wifi access will be provided at the conference venue. Conference participants each have a unique Username and Password combination printed on the back of their name tags.



Note: These credentials can be used for multiple devices, but please do not share them with anyone else. The credentials are unique to you.

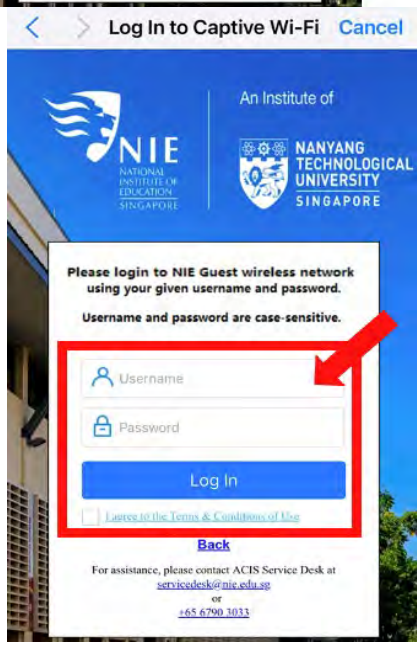
1. Connect your device to '**NIE Guest**' network.

2. A pop-up window will appear. Click on the '**For sponsored guest**' link.

3. Another pop-up window will appear for you to enter your **username** and **password**. These can be found on the back of your name tag.

4. Click 'agree' to the Terms & Conditions of Use

5. Click the '**Log In**' button.



6. Once connected, you will be redirected to a NIE feedback page. You are welcome to provide your feedback, or you can simply close the page.

7. Please note that each login to your 'NIE Guest' account is valid for 24 hours.

8. Repeat steps 1 to 7 to login for the following days.

Medical Services

If you are feeling unwell and need medical attention, you may refer to the following medical centres located on or near campus. Cost varies depending on the type of consultation and medication.
In an emergency, dial 995 or text 70995 for ambulance. For non-emergency conveyance by ambulance, dial 1777.

Fullerton Health @ NTU
36 Nanyang Avenue, #01-01
Singapore 639801
Mon to Fri: 8.30am to 9.00pm; Sat: 9.30am to 12.00pm; Sun & Public Holidays: Closed
Telephone: 6793 6828

Central 24-hour Clinic (Pioneer North)
959 Jurong West Street 92, #01-160
Singapore 640959
Open 24 hours
Telephone: 6251 2775

Other Amenities

A private room for nursing mothers and a prayer room (Surau) are available on campus. Please refer to the directions signs or enquire at the Secretariat Room.