

Global Chinese  
Academy for Science  
Education Research

# 2025 Conference

全球華人科學教育研究學會  
2025年會

## 可持續發展的科學教育： 創造更美好的未來

# Sustainable Science Education: Shaping a Brighter Future

3-4 January 2025  
Programme Book



### Organisers



### Co-organisers



### Supporters



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# 歡迎辭 Welcome Message

On behalf of the Local Organising Committee of GCASER 2025, it is our pleasure to welcome you all to the International Conference on “Sustainable Science Education: Shaping a Brighter Future”. Science education plays a crucial role in shaping a sustainable future for our world. By bringing together leading experts, early-career researchers, and passionate educators from Chinese societies, we aim to foster interdisciplinary dialogue, share best practices, and explore innovative approaches to science education that can positively impact the lives of students and communities.

In recent years, Chinese societies have witnessed a new wave of science curriculum reforms, as educators and policymakers work to address the challenges of the increasingly uncertain 21st century. As a prominent event in the field of science education research for Chinese learners, this conference aims to provide a platform for Chinese science education scholars from around the world to share their insights and inform the current tide of science education reform. Additionally, the academic community will have the opportunity to identify novel research questions and generate new theoretical frameworks by engaging with the perspectives of frontline science education practitioners.

Over the course of the two-day conference, we have curated an exciting and diverse lineup of events to inspire, challenge, and empower you. Our program features a series of captivating keynote addresses delivered by renowned experts, providing deep insights into the latest trends and innovations shaping the field of science education. Complementing the keynotes, we have organised engaging panel discussions that will explore complex issues from multiple perspectives, as well as paper presentation sessions highlighting cutting-edge research. Additionally, teacher forums will offer hands-on opportunities for skill development and collaborative problem-solving. Throughout these sessions, you will engage in thought-provoking discussions, exchange ideas, and build lasting connections with your global peers.

We would like to express our sincere gratitude to GCASER, the colleagues of Local Organising Committee, the co-organisers, project staff of EDUHK, supportive student helpers, and all the participants for their dedication and contributions to this important event. We are confident that this conference will be a resounding success, and we look forward to the rich discussions and collaborative opportunities that will emerge.

Thank you all for being here, and we wish you a productive and enjoyable conference.

Sincerely,



Peter Zhihong Wan, C&I, The Education University of Hong Kong

Keith Wing Kei Ho, SES, The Education University of Hong Kong



Dr. Peter Zhihong Wan  
萬志宏博士



Prof. Keith Wing Kei Ho  
何詠基教授

# 香港教育大學 課程與教學學系

## Department of Curriculum and Instruction

香港教育大學課程與教學學系作為當地社區教育和研究的中心，透過同事參與教學實踐和研究項目，我們與當地中小學建立了強大的網絡。正是透過這項工作，我們將最具創新性的教學、學習和評估方法帶入社區。我們的教職員在主要教育機構任職，例如課程發展處和香港考試及評估局、賽馬會慈善信託基金、非政府組織和學校董事會。

我們致力於三大核心領域的發展：課程、教學與評估。在**課程領域**，我們專注於教育改革和政策、課程設計、質量和評估等方面，具體包括課程開發、課程領導、課程整合和跨課程計劃。**教學領域**，我們提供規劃和實施課堂活動的基本知識和技能，重點關注教學模式、教學策略、課堂管理、創造力、創新教學法，以滿足學生的不同需求。在**評估領域**，我們將評估融入教學以支持學習，主要涉及評估改革和政策、學習評估、校本評估、各種評估策略、記錄和報告。

跨學科STEM教育是我們近年來發展的一大重點。基於本系的三大核心領域，我們在跨學科STEM課程理論、教學方法創新，評估設計和教師培訓方面進行卓有成效的嘗試，並運用跨學科方法對其進行多層次的研究。其成果在中小學廣為傳播，並推進了STEM教育理論和實踐的發展。

作為一個具有國際視野的學術單位，我們積極開展跨地區的研究和教學合作。我們不僅致力於課程發展和改進，更注重對外的教學與評估交流，以及不同的教育視域。我們為學生提供多元科目的學習經驗，並支持學校和機構在地方、區域和國際層面上進行教師的專業發展。

我們深信，通過與教育界的緊密合作和夥伴關係，我們能為社會服務，為教育政策和實踐的發展和改進做出貢獻。



# 香港教育大學 科學與環境學系

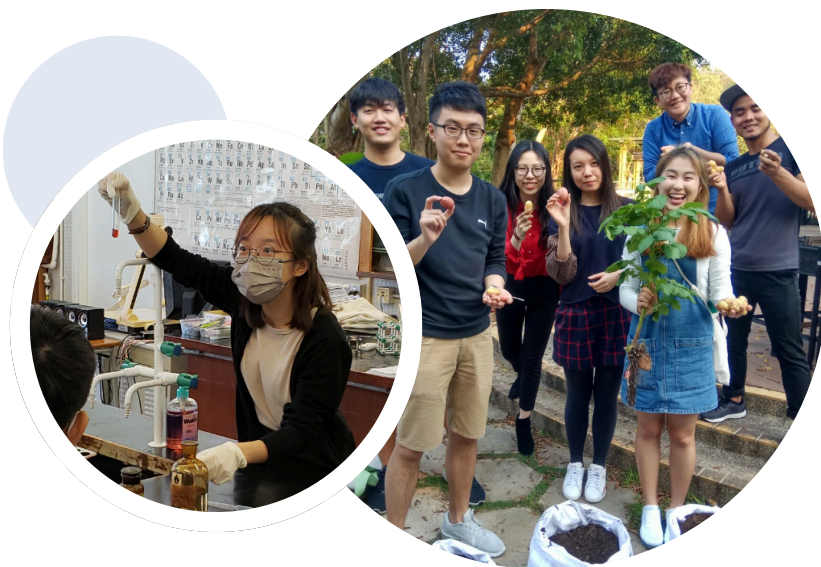
## Department of Science and Environmental Studies

科學與環境學系是香港教育大學促進科學及環境教育和研究的專業學術部門，提供中小學科學和環境教育學科等相關課程。學系的使命是促進和支持教師教育的發展，提供優質的科學教育及教師教育，致力培養老師成為懂得自我反思的教育工作者，並具備在課堂上進行高質素教學的能力及支持學校可持續發展的知識，技能和態度，成為科學和STEAM領域的教育專業人才。此外，學系一直十分注重發展科學和環境教育相關的研究及學術活動，提供不同機會讓學生參與以環境可持續發展為導向的科學研究，希望透過研究與教學活動互動及相輔相成，與學系中經驗豐富的科學家和教育家，共同致力於教學、研究和知識轉移等工作，在各自領域中取得卓越成就。

在**教育課程**方面，科學與環境學系提供多元且全面的本科及研究生課程，包括全新推出的本科課程《綜合環境管理（榮譽）理學士及科學教育（榮譽）學士（同期結業雙學位）課程》。該課程涵蓋環境管理和中小學科學教育兩大主修，提供跨學科的培訓，科學教育部分教授教育理論與技巧，並提供實習經驗，以培養能夠教授各教育階段科學課程的專業教師；環境管理部分包括科學、計算、社會經濟及法規等知識，並包含環境管理實習，通過跨學科學習，讓學生具備良好教育素養之餘，能夠在教育與環境科學中找到連結，促進社會的可持續發展。此外，我們還提供學位教師教育深造文憑課程，協助科學畢業生順利成為中小學科學教師。

在**研究**方面，學系的學術人員的研究範圍廣泛，涵蓋了物理學、化學、生物學、環境研究、科學教育和環境教育等領域，並致力於將研究成果轉化為實用教材，豐富大學、中學及小學的課程內容，並發展創新的教學方法與活動。學系開設不同的研究生課程，包括研究式及修課式研究生課程涵蓋哲學博士、哲學碩士、教育博士、教育碩士、可持續發展文學碩士及STEM教育文學碩士等課程。

本學系以放眼**全球**為方針，積極與國內外不同的大學及機構合作，以拓寬學生的學習經驗。透過海外交流、實地考察等合作，促進課程國際化，並進一步提高教學及研究質量。



Time	Programme Overview : 3 January, 2025
08:15-09:25	Registration
09:30-10:00	Opening Ceremony [D1-LP-04]
10:00-11:00	Keynote Address 1: 知識結構影響科學創造力的認知神經機制及其應用 [D1-LP-04] 特邀嘉賓: 胡衛平(教授)
11:00-11:15	Morning Tea Break
11:15-12:15	Invited Speech 1: Transforming primary science teaching through curated curricular resources: Insights from Singapore [D1-LP-07]   特邀嘉賓: 陳逸玲(教授)
	• Parallel Session 1.1 AI in Science Education [B4-LP-09]
	• Parallel Session 2.1 Comparative Research of Science Curriculum [B4-LP-08]
	• Parallel Session 3.1 Developing and Accessing STEM Creativity [D2-LP-10]
	• Parallel Session 4.1 Creative Problem-Solving in Science Classroom [D2-LP-09]
	• Parallel Session 5.1 Implementation of Project-Based Science Learning [D1-LP-08]
	大灣區科學教育圓桌會議 1: 大灣區科學教育協同創新的展望 [D1-LP-04] 特邀嘉賓: 胡衛平(教授), 林威廉(博士), 童海雲, 魏冰(教授)   主持: 萬志宏(博士)
	Workshop 1: AI在科學教學中的應用(粵語) [D3-LP-02]   香港教育大學課程與教學學系
12:15-13:30	Lunch
13:30-14:30	Keynote Address 2: Scientific Literacy and Science Curriculum: the Rationale and Approach in Macau [D1-LP-04]   特邀嘉賓: 魏冰(教授)
14:30-15:30	Keynote Address 3: Challenges and Opportunities of Science Education in the Artificial Intelligence Era [D1-LP-04]   特邀嘉賓: 邱美虹(教授)
15:30-15:45	Afternoon Tea Break
15:45-16:45	Invited Speech 2: My Journey of Research in Conceptual Change in Science [D1-LP-04]   特邀嘉賓: 周國強(教授)
	• Parallel Session 1.2 Eye-Tracking Research in Science Education [B4-LP-09]
	• Parallel Session 2.2 Cognitive Development in Science Education [B4-LP-08]
	• Parallel Session 3.2 STEM Attitude and Career [D2-LP-10]
	• Parallel Session 4.2 Cultivation Creativity through Science Education [D2-LP-09]
	• Parallel Session 5.2 Science Teachers [D1-LP-08]
	大灣區科學教育論壇 2: 系統開發科創課程, 全面培養創新人才: SWEETIE STEM教育的理念和實踐(粵語) [D1-LP-07]   特邀嘉賓: 羅金源, 胡漢基, 陳淑雪, 趙福誠   主持: 趙建豐(博士)
	Workshop 2: Engaging minds: Forensic Science as a Tool for Interdisciplinary Education(粵語) [D3-LP-02]   中華基金中學

Time	Programme Overview : 4 January, 2025
09:00-10:00	Keynote Address 4: STEM 抱負: 研究與發展 [D1-LP-04]   特邀嘉賓: 蘇詠梅 (教授)
10:00-11:00	Invited Speech 3: Agricultural Context as a Starting Point: A New Framework for Chinese Primary Science Curriculum [D1-LP-04]   特邀嘉賓: 張紅霞 (教授)
	• Parallel Session 1.3 Nature of Science [B4-LP-04]
	• Parallel Session 2.3 Science Textbooks [D2-LP-08]
	• Parallel Session 3.3 Exploring the Effects of STEM Learning [D2-LP-10]
	• Parallel Session 4.3 Identity in Project-Based Science Learning [D2-LP-09]
	• Parallel Session 5.3 Innovative Science Teaching [D1-LP-08]
11:00-11:15	Morning Tea Break
11:15-12:15	Invited Speech 4: 科學思維的發展與測評和跨文化比較 [D1-LP-04-Online]   特邀嘉賓: 包雷 (教授)
	• Parallel Session 1.4 AI in Science Education [B4-LP-04]
	• Parallel Session 2.4 Science Curriculum Development&Implementation [D2-LP-08]
	• Parallel Session 3.4 STEM Attitude and Career [D2-LP-10]
	• Parallel Session 4.4 Higher-Order Thinking in Science Education [D2-LP-09]
	• Parallel Session 5.4 Development of Assessment Tools [D1-LP-08]
12:15-13:30	Lunch
13:30-14:30	Invited Speech 5: 專案式學習助推育人方式變革的實務探索——基於物理學科區域推進經驗 [D1-LP-04]   特邀嘉賓: 李春密 (教授)
	• Parallel Session 1.5 Nature of Science, Socio-Scientific Issue and Inquiry [B4-LP-04]
	• Parallel Session 2.5 Science Curriculum Implementation [D2-LP-08]
	• Parallel Session 3.5 Exploring the Effects of STEM Learning [D2-LP-10]
	• Parallel Session 4.5 Affective Domains of Science Learning [D2-LP-09]
	• Parallel Session 5.5 Innovative Science Teaching [D1-LP-08]
	大灣區科學教育論壇 5: 在小學推進科學探究 - 教學和教師發展的視角 [D1-LP-07]   特邀嘉賓: 熊詩瑩, 童海雲, 高春艷   主持: 羅天 (博士)

<b>14:30-15:30</b>	• Parallel Session 1.6 IT-Enhanced Science Learning [B4-LP-04]
	• Parallel Session 2.6 Developing and Evaluating Science Curriculum [D2-LP-08]
	• Parallel Session 3.6 Cross-Disciplinary Learning [D2-LP-10]
	• Parallel Session 4.6 Higher-Order Thinking in Science Education [D2-LP-09]
	• Parallel Session 5.6 Science Teachers' PCK [D1-LP-08]
	大灣區科學教育論壇 6: 大灣區名師小學科學教學創新經驗分享 [D1-LP-07] 特邀嘉賓: 林聞凱, 李餘仙, 許廣玲, 劉少君   主持: 魏冰 (教授)
<b>15:30-16:00</b>	Afternoon Tea Break
	GCASER全體理事會議
<b>16:00-17:00</b>	• Parallel Session 1.7 Science Learning Process [B4-LP-04]
	• Parallel Session 2.7 International Perspectives on Science Teaching [D2-LP-08]
	• Parallel Session 3.7 Assessing Science Learning [D2-LP-10]
	• Parallel Session 4.7 STEM Learning [D2-LP-09]
	• Parallel Session 5.7 Review of Research [D1-LP-08]
	大灣區科學教育論壇 7: 科學教育中的批判思維培養 [D1-LP-07] 特邀嘉賓: 吳向東, 張新華 (博士), 唐小為 (博士), 解慧明   主持: 鄭嘉樂 (博士)

### 會議在線參與鏈接 (ZOOM Meeting Link)

Keynote Address 1-4, Invited Speech 2-5, 大灣區科學教育圓桌會議	<a href="#">ZOOM Link 1</a>
Parallel Session 1 (1.1-1.7)	<a href="#">ZOOM Link 2</a>
Parallel Session 2 (2.1-2.7)	<a href="#">ZOOM Link 3</a>
Parallel Session 3 (3.1-3.7)	<a href="#">ZOOM Link 4</a>
Parallel Session 4 (4.1-4.7)	<a href="#">ZOOM Link 5</a>
Parallel Session 5 (5.1-5.7)	<a href="#">ZOOM Link 6</a>
Invited Speech 1, 大灣區科學教育論壇 2-7	<a href="#">ZOOM Link 7</a>

# 主題演講 Keynote Address

1

## 知識結構影響科學創造力的認知神經機制及其應用

### Weiping Hu

胡衛平（教授）

Shaanxi Normal University



胡衛平，GCASER學會理事長，陝西師範大學二級教授，博士生導師。中國基礎教育品質監測協同創新中心副主任，現代教學科技教育部重點實驗室主任，科技創新後備人才成長規律協同研究中心主任。國家教材委員會專家委員會委員，國家義務教育課程改革專家委員會綜合協調組成員、課程標準框架專家組成員、科學課程標準修訂專家組組長，科學與技術共同核心素養專家組召集人，國家高中物理課程標準修訂專家小組成員，教育部高考內容改革專家委員會委員，教育部中小學心理健康教育專家指導委員會委員，教育部高等學校教育學教學指導委員會委員，中國青少年科技輔導員協會副理事長，中國教育學會科學教育分會會長等。全國20多個省的6000多所學校，美國、俄羅斯、瑞士、西班牙，以及中國台灣、香港和澳門等國家和地區的部分學校基於思維型教學理論推進教學改革，建立了1000多所學校的實驗基地，獲得國家級和省部級獎勵30餘項。

Professor Weiping Hu, second grade professor and doctoral supervisor of Shaanxi Normal University. Deputy Director of the Collaborative Innovation Center for Basic Education Quality Monitoring in China, Director of the Key Laboratory of Modern Teaching Technology of the Ministry of Education, and Director of the Collaborative Research Center for the Growth of Reserve Talents in Scientific and Technological Innovation. Member of the Expert Committee of the National Textbook Committee, member of the Comprehensive Coordination Group of the National Expert Committee on Compulsory Education Curriculum Reform, member of the Expert Group on Curriculum Standards Framework, leader of the Expert Group on the Revision of Science Curriculum Standards, convener of the Expert Group on Common Core Literacy of Science and Technology, member of the Expert Group on the Revision of National High School Physics Curriculum Standards, member of the Expert Committee on the Reform of College Entrance Examination Content of the Ministry of Education, member of the Expert Steering Committee for Mental Health Education in Primary and Secondary Schools of the Ministry of Education, member of the Steering Committee for Pedagogy Teaching in Colleges and Universities of the Ministry of Education, Vice Chairman of China Youth Science and Technology Counselor Association, President of Science Education Branch of China Education Society, etc. More than 6,000 schools in more than 20 provinces across the country, as well as some schools in the United States, Russia, Switzerland, Spain, as well as Taiwan, Hong Kong and Macao and other countries and regions have promoted teaching reform based on thinking teaching theory, established more than 1,000 school experimental bases, and won more than 30 national, provincial and ministerial awards.

### 摘要 Abstract

**Time** 10:00-11:00 3 Jan, 2025

**Location** [D1-LP-04]

知識是創新的基石，廣泛的、大量的知識儲備是創新的基礎。知識可以劃分為表象知識和言語知識。綜合應用腦科學與行為學的方法，系統研究了語義網絡結構與表象知識影響科學創造力的認知神經機制，研究發現：跨學科概念圖創作能力與科學創造力顯著正相關，高創造性個體的語義網絡表現出比低創造性個體更高的連通性、更短的距離；表象知識促進了科學知識的學習和基於科學知識的創造性觀點產生，表象與語義結合更有利於學生創造力的發展。依據本研究結果，在國家《義務教育科學課程標準（2022年版）》中打通了學科領域，強化了課程內容的綜合性，並探索了分科課程綜合化實施的路徑。

# 主題演講 Keynote Address

## 2 科學素養與科學課程：澳門的理念與做法

**Bing Wei**

魏冰（教授）

University of Macau



魏冰，北京師範大學學科教學論(化學)碩士、香港大學科學教育哲學博士(PhD)。現任澳門大學教育學院教授、博士研究生導師，兼任教育學院綜合科學課程主任、邵邦書院導師等職。主要從事科學（化學）教育的教學與研究，研究專長為中學理科課程發展、科學史及科學本質、中小學科學教師發展等。先後在各類中、英文期刊發表論文百餘篇，其中SSCI收錄期刊40餘篇，系多個中、英文學術期刊編委、顧問。作為計畫負責人先後承擔澳門特別行政區初、高中自然科學基本學力要求及課程指引的研製，先後負責多項各種類別的中小學科學教師培訓項目。

Prof. Bing Wei obtained Master's degree in chemistry teaching from Beijing Normal University and PhD in science education from the University of Hong Kong. Currently, Dr. Wei is a full professor at the Faculty of Education, University of Macau. His research mainly focuses on science curriculum in social context, the nature of science, and science teacher development. Dr. Wei has published over one hundred papers in peer-reviewed journals. He serves as an editorial board member and advisor for several academic journals. As a project leader, he has been involved in the development of the BRAAs for natural sciences in primary and secondary schools in Macau SAR.

### 摘要 Abstract

**Time** 13:30-14:30 3 January, 2025

**Location** [D1-LP-04]

提升全體學生的科學素養水準是世界各國中小學科學教育追求的首要目標。在本報告中，魏冰教授基於自己的學術研究和課程發展經驗分享三個相關問題：科學素養的含義和理論；澳門自然科學課程改革；科學素養在澳門自然科學基本學力要求中的落實。基於澳門的經驗，作者提出在科學課程改革中落實科學素養理念需要注意連貫性、適切性和時代性。

# 主題演講 Keynote Address

## 3 Challenges and Opportunities of Science Education in the Artificial Intelligence Era

**Mei-Hung Chiu**

邱美虹 (教授)

National Taiwan Normal University



邱教授的研究興趣與專長在科學教育、科學概念建構與改變、科學建模教學、科學課程及另類評量。她的研究觸角延伸到以人臉辨識系統探討學生面對認知衝突的科學現象時臉部微表情的變化與學習的關係，以及利用新興科技之擴增實境和虛擬實境探討科學學習之成效。邱教授曾任國際純粹與應用化學聯盟(International Union of Pure and Applied Chemistry, IUPAC)化學教育委員會(Committee on Chemistry Education)主任委員(2012-2015)、IUPAC 最高執行委員會常務委員(Executive Committee)(2016-2019, 2020-2023)，以及國際科學會(International Science Council)治理委員會委員(2022-2024)。邱教授於2016-2017年獲選擔任美國科學教育學會(National Association for Research in Science Teaching, NARST)理事長，為非英語系國家學者擔任該學會理事長的第一人。邱教授曾於2009年獲得亞洲化學會(Federation of Asian Chemical Societies, FACS)化學教育傑出貢獻獎、2016年獲得東亞科學教育學會(Eastern-Asian Science Education Association, EASE)傑出貢獻獎和2021年獲得IUPAC化學或化工傑出女性獎(Distinguished Woman in Chemistry or Chemical Engineering)。

Mei-Hung Chiu is a Professor Emerita of the Graduate Institute of Science Education of the Taiwan Normal University. Her research areas include (1) eliciting students' conceptual construction and conceptual change in science education, (2) promoting model-based and modeling-based instruction and developing students' modeling competence in science education, (3) investigating the effectiveness of the use of counter-intuitive scenarios via facial recognition system and exploring whether facial microexpression state changes can be used to identify optimal moments of conceptual change in science learning, and (4) applying augmented reality for learning structures of organic compounds. She received the Distinguished Contribution to Chemical Education Award from the Federation of Asian Chemical Societies (FACS) in 2009, the Distinguished Contribution to Science Education Award from the Eastern-Asian Science Education Association (EASE) in 2016, and the Distinguished Woman in Chemistry or Chemical Engineering from International Union of Pure and Applied Chemistry (IUPAC) in 2021. She served as the President of the National Association for Research in Science Teaching (NARST) based in the USA from 2016- 2017, the chair of the Committee on Chemistry Education (CCE, 2012-15), a member of the Bureau and the Executive Committee (2016-2019, 2020-2023), and a member of the Governing Board of the International Science Council (2022-2024).

### 摘要 Abstract

**Time** 14:30-15:30 3 January, 2025

**Location** [D1-LP-04]

As the rapid advancement of artificial intelligence continues to exceed expectations, the challenge of teaching and learning science grows increasingly urgent for researchers, educators, students, school stakeholders, and policymakers. In response to this need, the OECD (2019) launched the 'Future of Education and Skills 2030' project (now transitioning to Education 2040) to equip students with the knowledge, skills, attitudes, and values essential for the future, fostering confidence to navigate unfamiliar and AI-driven environments. Similarly, UNESCO (2022) issued guidelines for planning AI curricula for K-12, helping nations design curricula and implement strategies for developing AI competencies. These documents, along with existing research in AI and science education, highlight the growing need to connect cognitive understanding and skills taught in schools and those needed for future job markets. In this presentation, I will explore the challenges of teaching and learning in an AI-driven era and the opportunities AI—particularly machine learning—offers for reshaping interdisciplinary curricula, textbooks, instructional strategies, and assessments to enhance students' up-to-date scientific literacy. Lastly, I will address the potential challenges and strategies of integrating AI into science education.

# 主題演講 Keynote Address

## 4 STEM 抱負: 研究與發展

### Wing Mui Winnie So

蘇詠梅 (教授)

The Education University of Hong Kong



蘇詠梅教授自1990年代開始專注於科學教師教育工作。現任香港教育大學科學與環境學系專業顧問; 國家教育部現代教學技術教育部重點實驗室兼職教授; 重慶師範大學初等教育學院客座教授; 及佛山大學人民與教育學院客座教授。

Professor Wing Mui Winnie So has focused on science teacher education since the 1990s. Currently, she is a professional advisor at the Department of Science and Environment, The Education University of Hong Kong; an adjunct professor at the Key Laboratory of Modern Teaching Technology, Ministry of Education; a visiting professor at the School of Elementary Education, Chongqing Normal University; and a visiting professor at the School of People and Education, Foshan University.

#### 摘要 Abstract

**Time** 9:00-10:00 4 January, 2025

**Location** [D1-LP-04]

為了促進 STEM 創新和經濟增長，需要大量相關學科的大學畢業生。為此，需要在中小學層面加強 STEM 教育，激發學生對 STEM 的興趣和抱負。因此，培養和提升學生的 STEM 職業抱負已成為 STEM 教育的新興研究熱點。但是大部分研究針對中學和大學學生，而針對小學生的研究有限，儘管早期對 STEM 職業的興趣會影響學生以後的職業興趣或選擇。本演講重點介紹最近針對香港小學生的 STEM 願望進行的研究與發展，並將整合各項研究的結果，以提高教育工作者對 STEM 抱負的了解。

# 特邀報告 Invited Speech

## 1 Transforming primary science teaching through curated curricular resources: Insights from Singapore

**Aik Ling Tan**

陳逸玲 (教授)

Nanyang Technological University



陳逸玲 (Aik Ling Tan)，新加坡南洋理工大學國立教育學院自然科學與科學教育系副教授，國立教育學院自然科學與科學教育系副主任。國立教育學院STEM教育研究中心meriSTEM@NIE創始成員之一。2005年，在新加坡國立教育學院任教，從事生物學教學法和整合性STEM相關課程的教學。多次榮獲由新加坡國家教育研究所頒發的教學表彰獎。在此之前，她曾在新加坡立化中學從事10年中學生物學及綜合科學教學工作。她目前的研究興趣主要集中在學生科學學習觀念、科學教師專業發展和STEM教育等領域。重點關注學生在課堂上與同伴、學習資源和操作材料之間的互動；科學教師的科學探究理念、課堂教學行為以及教學過程中的適應性實踐；STEM綜合課程和STEM教育領導力。基於這些研究，已發表期刊論文60餘篇，學術專著5部，會議論文和書籍章節若干篇。目前正在主持STEM教育，教師專業發展，學習資源建設等相關研究項目共7項。曾獲得多項國內外學術研究相關獎項，包括2019年新加坡國家研究所卓越研究獎；2014年由Routledge 教育出版社頒發的科學教育領域最受歡迎文章等。

Aik-Ling Tan is an Associate Professor and Deputy Head (Teaching & Curriculum Matters) at the Natural Sciences and Science Education (Academic Group), National Institute of Education (NIE), Singapore. She is also a core team member with the Multi-centric Education, Research and Industry STEM Centre at NIE (meriSTEM@NIE). Her research focuses on the scholarship of science teaching and learning, science teacher professional development and STEM education.

### 摘要 Abstract

**Time** 11:15-12:15 3 January, 2025

**Location** [D1-LP-04]

Curricular resources play an important role in supporting high quality primary science teaching and learning. The peculiar nature of science learning (such as language, representations, experimentation, explanations) suggests that young learners are required to develop science-related competencies to learn science successfully. To this end, I describe theoretical ideas related to Vygotsky's ideas of mediation and zone of proximal development as a possible way to understand how support can be provided to young learners to learn the scientific concepts as they encounter and interact with the natural and physical world. I make the case for systematic usage of curricular resources such as textbooks, activity books, physical manipulative, online learning resources and teaching and learning guides to enable young learners of science to transform their spontaneous ideas formed from personal discovery to disciplinary thinking and practices in science. Rather than just focusing on the affordances of curricular resources for science teaching and learning, I consider the multiple factors and dialectic interactions of users (both teachers and students) with the curricular resources to understand the forms and extend of science learning that results. The ideas presented in this talk originate from a deep belief that learning primary school science requires resources to create embodied experiences for learners to visualize natural phenomena around them so that they can make sense of phenomena and transform these experiences into meaningful disciplinary knowledge.

# 特邀報告 Invited Speech

## 2 My Journey of Research in Conceptual Change in Science

**Guoqiang Zhou**

周國強 (教授)

University of Windsor



周國強博士是加拿大溫莎大學教育學院終身教授，博士生導師。曾擔任教育學院副院長，負責教師教育計畫的行政管理和課程設置。周教授2002年從加拿大阿爾伯塔大學獲得科學教育博士學位。出國前周教授在國家課程教材研究所(人民教育出版社)從事物理教材的編寫和出版工作。博士畢業後，曾先後任教於加拿大阿爾伯塔大學和美國紐約市立大學。周教授科研領域涵蓋科學教育、教師教育、比較和國際教育等領域。周教授曾擔任溫莎大學教務會、課程發展委員會、本科課程評審委員會、資訊科技督導委員會委員；溫莎大學教育學院科研委員會主席，研究生課程委員會主席。擔任加拿大多倫多大學，英屬哥倫比亞大學，女皇大學等10多所大學的教授職稱評定外審專家和博士生論文外審專家。曾主持溫莎大學教師教育新課程的制定，參加修訂安大略省教師教育標準。

Dr. Zhou is a tenured professor at the Faculty of Education at the University of Windsor, Canada, and a Ph.D. supervisor. He previously served as the Associate Dean of the Faculty of Education, overseeing the administration and curriculum design of teacher education programs. Dr. Zhou obtained his Ph.D. in Science Education from the University of Alberta, Canada, in 2002. Before going abroad, he worked at the National Institute for Curriculum and Teaching Material Research (People's Education Press) in China, where he was involved in the writing and publication of physics textbooks. After earning his Ph.D., he taught at the University of Alberta, Canada, and the City University of New York, USA. Dr. Zhou's research areas cover science education, teacher education, comparative and international education, among others. Dr. Zhou has served as a member of the University of Windsor's Senate, the Curriculum Development Committee, the Undergraduate Program Review Committee, and the Information Technology Steering Committee. He has also been the Chair of the Research Committee and the Graduate Program Committee of the Faculty of Education at the University of Windsor. He serves as an external evaluator for professor promotions and as an external examiner for doctoral theses for over 10 universities, including the University of Toronto, the University of British Columbia, and Queen's University. He has led the development of a new teacher education curriculum at the University of Windsor and participated in revising the teacher education standards in Ontario.

### 摘要 Abstract

**Time** 15:45-16:45 3 January, 2025

**Location** [D1-LP-04]

Over the last four decades, student preconception and conceptual change in science have been a significant topic in the literature of science education. Scholars' perspectives in this research area have gone through various stages with changing philosophical stands. Accordingly, educational implications of the research have differed over the time. Most scholars have turned away from a colonial perspective and approach to a more postcolonial and democratic approach. This change realizes the center of students in teaching and learning and calls for more humanity aspects of science. Dr. Zhou will discuss the evaluation of conceptual change research and share his insight about where this research is going for the future.

# 特邀報告 Invited Speech

## 3 以農業情境為起點：中國小學科學課程新框架

**Hongshia Zhang**

張紅霞（教授）

Nanjing University



張紅霞，南京大學教育研究院、陶行知教師教育學院教授；南京大學課程建構與評估委員會委員，南京大學教師教學發展中心顧問委員會委員，南京大學高等教育研究與評估中心顧問。主要研究領域為科學教育、高等教育、教育研究方法、教育與文化；主要著作有：《科學究竟是什麼》《教育科學研究方法》《大學課程與教學：原理與問題》（第一作者）《小學科學課程與教材》（第一作者）。在國內外重要刊物發表學術論文百餘篇；培養碩士、博士研究生百餘名。主要社會兼職：中國教育學會科學教育分會常務理事；義務教育國家課程教材小學《科學》（教科版）主編。

Hongshia Zhang, a professor at the Institute of Education and Tao Xingzhi College of Teacher Education at Nanjing University; a member of the Curriculum Construction and Evaluation Committee at Nanjing University, an advisory committee member of the Teacher Education and Development Center at Nanjing University, and an advisory committee member of the Center for Higher Education Research and Evaluation at Nanjing University. Her main research areas include science education, higher education, educational research methods, and education and culture; her main monograph publications include *What is Science? Educational Research Methods; University Curriculum and Teaching: Principles and Issues* (first author), and *“Elementary Science Curriculum and Teaching Materials”* (first author). She has published over a hundred academic papers in important domestic and international journals. She has cultivated over a hundred master’s and doctoral students. Her main social positions include: Executive Director of the Science Education Branch of the Chinese Education Society; and the chief editor of the elementary school “Science” textbooks (by Educational Science Publication House) for the national curriculum of compulsory education.

### 摘要 Abstract

**Time** 10:00-11:00 4 January, 2025

**Location** [D1-LP-04]

一些關於中國小學科學教師的研究顯示，他們的科學素養在過去幾十年的發展甚微，在科學本質觀發展模式上呈現出一種「倒置」現象，即後現代觀點比現代觀點更強。本研究首先透過「認識論認知」和「文化響應性教育」等理論對這種現象進行分析，然後基於一項歷時五年的鄉土課程開發的研究發現，提出了一種全新的中國小學科學課程框架，即以農業情境為起點，將當地鄉土資源作為課程內容和教學設計的根本，從而達到調動學生、教師和家長的科學教學積極性和提高其科學認同的目的。

# 特邀報告 Invited Speech

## 4 科學思維的發展與評測和跨文化比較

**Lei Bao**

包雷 (教授)

The Ohio State University



包雷教授是美國俄亥俄州立大學物理系和教育學院雙聘教授，國際華人物理及天文學學會會長。研究領域包括：科學及物理學科教育，科學思維模型和測評，知識整合深度學習模型和測評，中美教育比較，認知理論模型，複雜系統模型，等等。包雷教授主持多項美國國家科學基金項目，主要研究成果發表於SCIENCE等國際知名期刊。

Dr. Lei Bao is a professor in the Department of Physics and the College of Education at The Ohio State University. He also serves as the President of the International Organization of Chinese Physicists and Astronomers (OCPA). His research areas include science and physics education, scientific reasoning models and assessments, knowledge integration and deep learning models, comparative education between China and the U.S., cognitive theory models, and complex systems modeling. Professor Bao has led multiple research projects funded by the U.S. National Science Foundation (NSF), with his major findings published in internationally renowned journals such as Science.

### 摘要 Abstract

**Time** 11:15-12:15 4 January, 2025

**Location** [D1-LP-04-Online]

本報告聚焦於新時代國際教育目標的演變趨勢，著重分析了其核心認知能力培養的新要求，不僅涵蓋了建構既具深度又具廣度的知識架構，也強調了科學思維與創造力等高端思維技能的培育。科學思維和創造力正成為科學教育研究的核心方向。本報告將整理科學思維研究的重要結果並介紹關於科學思維評估和培養的最新的理論和實證研究發展，比較中美研究的新進展。基於研究結果，探討這些國際趨勢與研究成果對學生科學思維培養的潛在啟示與策略建議。

# 特邀報告 Invited Speech

## 5 專案式學習助推育人方式變革的實務探索——基於物理學科區域推進經驗

**Chunmi Li**

李春密（教授）

Beijing Normal University



李春密，教育學博士，北京師範大學物理與天文學院教授，博士生導師。主要研究方向為物理課程與教學理論，學科能力發展研究、物理實驗教學研究、物理教學評估研究等。主持自然科學基金、國家社會科學基金教育學重點課題多項課題。完成教材或著作20餘本，發表學術論文170餘篇。教育部基礎教育物理教學指導專委會副主任委員兼秘書長，中國教育學會物理教學專業委員會副理事長兼秘書長，義務教育物理課程標準修訂組核心成員，普通高中物理課程標準修訂組核心成員，高職物理課程標準修訂組核心成員，國培計畫首批訓練專家等。

Chunmi Li, PhD in Education, is a professor and doctoral supervisor at the School of Physics and Astronomy, Beijing Normal University. His main research areas are Physics Curriculum and Teaching Theory, Subject Competency Development, Physics Experimental Teaching, and Physics Teaching Assessment. He has served as Principal Investigator for multiple key projects funded by the Natural Science Foundation and National Social Science Foundation in the field of education in China. He has authored or co-authored over 20 textbooks or monographs, and published more than 170 academic papers.

### 摘要 Abstract

**Time** 13:30-14:30 4 January, 2025

**Location** [D1-LP-04]

基於新課標理念和當前教學改革實際，本報告將深入探討項目式學習的內涵與特征，強調其以學生為中心的學習模式和跨學科整合的優勢。通過具體案例，本報告還將詳細分析項目學習的實施流程，包括主題選擇、團隊協作、實踐探究和成果展示等環節，突出其在物理學科中的應用效果和實踐價值。結合區域推進經驗，其將系統梳理了項目學習對學生批判性思維、問題解決能力及團隊合作精神等綜合素養提升的積極影響，充分體現了項目式學習在育人方式變革中的重要作用，為未來教育實踐提供了有益借鑒和啟示。

# 粵港澳大灣區科學教育論壇

## Greater Bay Area Science Education Forum

### 01 大灣區科學教育論壇 1(圓桌會議): 大灣區科學教育協同創新的展望

主持：萬志宏 (博士)

嘉賓：胡衛平 (教授)、林威廉 (博士)、童海雲、魏冰 (教授)

建設粵港澳大灣區是中央政府提出的一項重要國策。作為全國的科技創新中心，粵港澳大灣區的持續發展離不開高品質的中小學科學教育。通過加強科學課程的改革與實踐，提升教育品質，大灣區將為科技創新提供源源不斷的人才支援。大灣區各個城市同根同源，在文化上具有一定的相似性，同時又各自擁有獨特的特點和優勢。如何強化各城市之間的合作，實現資源互通和優勢互補，是加速大灣區科學課程改革、提升教學品質的必由之路。本次論壇邀請了國家義務教育科學課程標準修訂組組長胡衛平教授，以及來自香港、深圳和廣州的科學課程改革專家林威廉博士、童海雲教研員和黃志紅研究員。他們將深入探討大灣區科學教育協同創新的意義、機遇與挑戰，並為大灣區科學教育的未來發展提供寶貴的意見與建議，以推動區域科學教育事業的全面進步。

### 02 大灣區科學教育論壇 2: 系統開發科創課程，全面培養創新人才：SWEETIE STEM教育的概念與實踐

主持：趙建豐 (博士)

**報告1:** SWEETIE教學法中T (反思鞏固) 的作用

**報告者:** 趙福誠

**報告摘要:** SWEETIE教學法分為創造情境、提出問題、構思設計、實踐探索、反思鞏固、改進創新、延展學習7個步驟。大家在使用的過程中經常忽略“反思鞏固”，也就是第五個字母T。本報告講結合自己實踐的經驗來分析SWEETIE教學法中T (反思鞏固) 的重要作用，以及做好這個步驟需要注意的問題。

**報告2:** 從師生探索體驗反思如何系統化學習工程概念

**報告者:** 胡漢基

**報告摘要:** 本報告探討了在思維奇課程學習下，師生如何從體驗中系統地探索工程概念。本工程學習課程提供階梯式的體驗內容，以有趣的方式讓學生深入理解工程發展的脈絡。課程設計讓師生易於掌握，提供場景任務改良，同時輔以影片輔助，有助於照顧學習差異。透過這樣的課程設計，師生能深刻反思如何以更佳模式探索和掌握工程概念，藉以提升學習效果。

**報告3:** 正向與反向工程在SWEETIE課程中的應用

**報告者:** 羅金源

**報告摘要:** 工程設計是STEM教育的重要方法。人們往往以為工程設計只有一種方法。本次報告將集中介紹正向和反向工程這兩種普遍使用的方法，分析它們之間的差異和聯繫。最後將分享如何在SWEETIE課程中靈活地使用這兩種方法。

**報告4:** SWEETIE STEM的教學實踐與評估

**報告者:** 陳淑雪

**報告摘要:** SWEETIE教育理念強調「思考、創作、探索」的重要性，旨在培養學生的創新能力和批判性思維。在實踐中，我們為學生創造了多樣化的學習空間，鼓勵他們自由發揮與合作，並重視留白的教學策略，讓學生有機會在過程中自主探索，而不僅僅是追求完成的結果。在評估方面，我們採取了多元化的方法，著重於學生在學習過程中的參與、創新思維及解決問題的能力，而非僅僅依賴最終作品。這種評估方式有助於全面了解學生的學習狀況，並指導後續的教學改進。本次報告將簡要介紹如何透過這些實踐，提升了學生的STEM能力，並促進他們的自信心和對學習的熱情。

# 粵港澳大灣區科學教育論壇

## Greater Bay Area Science Education Forum

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### 大灣區科學教育論壇 3：

### 在世界和國家發展的脈絡下，香港科學教育的前進路徑

主持：李偉展 (博士)

**報告1：** 香港科學教育新動向

**報告者：** 林威廉 (博士)

**報告摘要：** 香港教育局大力推動科學教育，配合數位教育策略，在科學學習中豐富創科學習元素和推動跨範疇學習，做好科學教育的「加法」，提升學生的科學素養和創新精神。為達此目標，在香港教育局透過一系列的策略，包括更新中小學階段的科學課程、加強科學教師培訓、資源支持等，實踐課程發展與課程支持同步，以及資優和普及並重的進路。在全社會大力支持下，提供課堂內外的多元學習經歷，把科學和創科學習連繫真實世界，培育學生對科學和創科發展的志向。

**報告2：** 小學科學學習的關鍵問題

**報告者：** 蘇詠梅 (教授) 陳瑛 (博士)

**報告摘要：** 小學生的科學學習經驗影響他們隨後進一步的學習及職業選擇，本報告透過實例探討香港老師對多個可能影響兒童的科學學習的關鍵問題的想法，透過實證讓老師對兒童科學學習有明確的理解，為小學科學學習的計劃和發展、及科學課堂的需求提供適當的建議。

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### 大灣區科學教育論壇 4：

### 大灣區戶外科學教育：理念、實施和效果

主持：吳向東

**報告1：** 紅樹林自然保護區中的科學教育－龍高集團寶龍外國語學校的創新實踐

**報告者：** 高暉

**報告摘要：** 本校是深圳市“未來學校”，依托寶龍科技城的地緣優勢，打造“家門口研學”的科創課程。課程採用「4+1+1」模式，透過建立開放融合的教育教學空間，旨在培養學生的創新思維和實踐能力，讓他們像職業工程師一樣思考問題、動手操作、發明與創造。本校所進行的紅樹林博物學課程，數百名學生走進紅樹林國家級保護區，指導學生像博物學家一樣觀察，像科學家一樣思考，鼓勵學生自己發現問題，提出問題，透過多種方式尋求問題的可能答案。從宏觀到微觀，巧妙融合語文、美術、科學、物理、生物、英語、道法等不同學科開展跨學科學習，有效激發了學生的學習熱情，同時培養了他們的團隊協作精神、批判思維和創新能力。這項創新教育實踐，為學生的全面發展奠定了堅實基礎。

**報告2：** 自然觀察中的科學探究與批判性思考培養

**報告者：** 高旅威

**報告摘要：** 大自然中豐富多彩的生物與環境是孩子學習科學和發展批判性思考的寶貴資源。本報告將探討如何引導學生進行自然觀察，並引導他們在觀察過程中發現問題、提出問題以及解決問題的策略。此外，報告還將探討如何透過這些活動培養學生求真、求善、求美的價值觀以及發展批判性思考。

**報告3：**「行走的課堂」—校外科學實踐探索

**報告者：** 黃薇 林建州

**報告摘要：** 深圳中學龍崗學校（集團）依山郡小學創新推出“行走的課堂”，深入挖掘週邊資源，進行特色科學實踐活動。課程引導學生走出教室，親歷自然與社會，進行實地科學探究，旨在全面發展學生潛能。活動包括「自然動物奇趣之旅」等，以保護好奇心、激發探究欲為宗旨，透過問題引導，促進學生深度參與觀察、體驗、思考與探索。這個模式有效提升了學生的科學素養和問題解決能力，並實現了科學教育的全方位增值。

# 粵港澳大灣區科學教育論壇

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### 05 大灣區科學教育論壇 5： 在小學推廣科學探究- 教學與教師發展的視角

主持：羅天(博士)

**報告1：**如何發揮集體論證在科學教學中的作用

**報告者：**童海雲

**報告摘要：**集體論證作為科學實踐的重要組成部分，是在教師組織下的學生對探究問題進行公開研討的過程。集體論證可以透過多種形式的論證活動，加強證據的比較和評估、觀點的分享和共建等，幫助學生提昇科學理解力、理性化實踐和良好的科學品質。

**報告2：**探究實踐研訓在科學教師專業發展的探索

**報告者：**熊詩瑩

**報告摘要：**小學科學教師專業發展受多種因素影響，在當下國家基礎教育課程教學改革背景下，透過探究實踐工作坊的研訓方式提升小學科學教師的科學教育素養。本報告結合區域實踐透過個案分析介紹探究實踐工作坊的設計與內容，明確目標、形式和實踐方法，闡述工作坊的收穫與影響，包括對教師專業發展、學生學習以及學校科學教育的改進。

**報告3：**讓科學教育與萬物連結：基於大觀念的「大科學課程」教學設計與實踐

**報告者：**高春艷

**報告摘要：**科學課是體現科學本質的綜合性基礎課程，具有實踐性。本報告聚焦於「大科學課程」的建構與實施，主要目標是推動科學教育的教學改革創新、打造師生科學教育的社會大課堂。報告以案例的方式講述如何構建“基於大觀念”的科學思維課堂；如何設計走向大自然、走進真實生活的“大科學課程”；如何打造家門口“5分鐘科學教育生活圈”，建設“1平方米家庭科學實驗室”，以推動科學教育走進千家萬戶。

### 06 大灣區科學教育論壇 6： 大灣區小學科學教學創新經驗分享

主持：魏冰(教授)

**報告1：**粵港澳大灣區科學教育教學實務現況、問題與對策

**報告者：**林聞凱

**報告摘要：**本報告以粵港澳大灣區經濟較發達的六個城市為例，基於計劃行為理論，探討小學科學教師科學教學實踐的關鍵影響因素。透過建構結構方程模型，分析教學態度、主觀規範、知覺行為控制對科學教學實踐及其具體環節（如內容滲透、教學擴展和跨領域合作）的影響。提出優化科學教師培訓系統、強化跨領域合作與建構資源共享機制、提昇科學教師的教學能力及專業素養等改進措施。

**報告2：**基於專案式學習的小學科學STEM教育

**報告者：**李餘仙

**報告摘要：**專案式學習（PBL）與STEM概念的結合在小學科學教學中的應用，對於促進學生科學核心素養的落地具有重要意義。本報告將分析小學科學PBL-STEM課例的特徵、發展原則、實施策略及評估體系，並透過《未來體育館》案例展示其實務應用，闡述模式在提升學生解決實際問題能力上的有效性。

**報告3：**基於學段特徵的小學科學「教學-評」一體化的區域範式案例

**報導者：**許廣玲

**報告摘要：**「教學-評」整合對提升小學科學教學品質與學生科學素養的重要角色。在目前小學科學教學中課堂評估有評估偏離教學、目標定位不準等問題。本報告將簡要從教師現實困境分析，進行評估先行的教學設計，以學段特徵展開「教學-評」一體化實施範式提煉，借助AI平台在區域內共建共研共享科學評估資源，整體提升區域師生科學素養。

**報告4：**小學科學「三段三階」科創課程體系建構與實踐探索

**報告者：**劉少君

**報告摘要：**「三段三階」科創課程依托國家課程，遵循1+1建設思路，核心在於「學以致用、做中學、學中創」。課程以知識學習與動手實作為主線，依照「基礎—個性—特長」三個階梯逐步攀升，涵蓋低、中、高三個學段，實現螺旋式上升。本課程旨在全面發展學生核心素養，同時關注個別興趣與專長，著力培養學生的科學素養、創新精神、實踐能力及問題解決能力。報告將概述科創課程體系建構架構、核心內容、實施步驟及應用成效。

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### 07 大灣區科學教育論壇 7: 科學教育中的批判性思考教學

主持：鄭嘉樂 (博士)

**報告1：創造促進批判性思考的課堂脈絡**

**報告者：**唐小為 (博士)

**報告摘要：**培養批判性思考是當前科學教育的重要目標。從認識論資源理論的角度來看，批判性思考是眾多認知方式中的一種，學生是否在使用批判性思維，取決於他是否認為這樣的思維是特定學習情境所需要的，以及他是否具備在特定問題情境中進行有意義建構、反思、質疑的認知資源。在本報告中，研究者透過幾個案例的分析，嘗試梳理能催生批判性思考的課堂脈絡應具備怎樣的特質。

**報告2：批判行動教學：在充滿挑戰的時代為學生賦能**

**報告者：**張新華 (博士)

**報告摘要：**CALE (關鍵行動學習交流) 幫助學生應對社會複雜問題如氣候變遷等，培養能動性和社區意識。CALE 的課程架構結合知識、批判與行動 (縱軸)，以及個人、社區與全球 (橫軸)，促進學生在深度學習與實踐中擴展批判性視野和行動力。2020年成立的 CALE@中國跨學科教師共同體，透過組織 STEM 課程設計工作坊和教學實踐，助力教師專業發展，為學生注入主動學習和批判思維的新動力，為教育應對當代挑戰提供了創新路徑。

**報告3：協同AI智能體的批判性思考教學**

**報告者：**吳向東

**報告摘要：**

在AI時代，批判性思考成為學生必備的核心素養。為有效提升學生的批判性思維，我們研發了AI智能體“有趣的科學吳老師”，透過高頻對話與即時回饋，鍛鍊學生的思維嚴謹性與多樣性。同時，配對的「智問師」與「智問師2號」工具提供教師教學提問支架，明確提問在布魯姆學習目標分類中的認知層級，協助教師引導學生進行高階思維訓練。實踐表明，這些AI智能體在科學教學中的課前與課中應用，顯著促進了批判性思考的教學效果。

**報告4：提昇科學素養 培養創新精神**

**報告者：**解慧明

**報告摘要：**

科學教育是提升全民科學素養的重要前提，是實現高水準科技自立自強的根本保障。習近平總書記作出「在教育‘雙減’中做好科學教育加法」重要指示以來，西安市教育科學研究院在西安市教育局的領導下，堅決扛起政治責任，前瞻佈局、科學策劃，秉承「政治建院、研究立院、人才強院、服務興院」，發揮教育科研優勢，以“科學家精神+”、“質量監測+”、“實驗教學+”、“思維實踐+”、“STEAM教育+”、“數位科技+”、“課堂創新+”、“數位繪畫+”八大創新舉措，推動中小學科學教育取得重要進展和關鍵突破；實施科學教育「一十百千萬」工程，一體化推進教育、科技、人才高品質發展；構建「大中小學整合」科學教育體制機制，學校課堂教學方式不斷改進，館校結合、家校協作日漸完善；學生家國情懷及好奇心、想像力、探求欲的有效培養模式正在逐步形成，學生科學素質穩定提升。

# 教師工作坊 Teacher Workshop

## 01 「智」為科學：中學教師如何應用人工智能於初中科學教學？

張家政博士  
香港教育大學

在2024年施政報告中，政府推動利用人工智能（AI）輔助中學科學的教學與學習。在這次工作坊中，講者將與參加者分享如何運用免費軟件來加深學生對科學實踐及方法的認識。示範的免費軟件包括 Teachable Machine、Orange 及 Scratch CreatiCode，這些工具如何應用於初中科學課程中。例如，參加者將有機會使用 Teachable Machine 訓練 AI 模型來進行生物分類，從而學習科學方法的多元性。另外，參加者還會了解如何使用 Orange Data Mining 來分析及預測科學數據，以及如何引導學生思考科學實踐與人工智能的關係。最後，講者將示範如何使用 Scratch CreatiCode 製作人工智能聊天機械人，模仿與科學家的對話，促進學生對科學本質的學習。在工作坊結束時，講者與參加者將一起反思在科學教學上的機遇及挑戰，並討論講者在學術期刊發表的教學模型，以幫助教師和學生思考科學與人工智能之間的相互關係。

## 02 啟發思維：鑑證科學作為跨學科教育的媒介

陳靖淇  
中華基金中學

鑑證科學是一門結合不同科學範疇及應用的媒介，主要以破案為首要目標。同學需要透過觀察，這是科研中最重要元素，並結合在初中和高中的科學知識來解決案件。這樣的學習讓學生明白他們獲得的知識能夠在未來的職場上或日常生活中應用，同時也能從活動中反映出同學的思維，進而引入價值教育。該鑑證科學課程採用抽離式教育的方式，通常在聯課活動中進行。每次課程能容納約60到80位學生，並讓他們與不同學習程度的同學組成小組共同破案。這樣的設計不僅促進了合作學習，也提高了學生的社交技能和團隊合作能力。目前，此教案已在韓國2024年國際教師獎中獲得”Next Frontier of STEAM”的榮譽。

## 03 混合式小學工程設計的教學

廖怡康 謝道擎  
香港教育大學

工程設計是小學新科學課的新範疇，也是此次課程改革的重點和難點。思維奇(SWEETIE)是由香港大學萬志宏博士創立的科創教育理論，其參考工業革命的四個階段，把中小學設計導向的STEM課程組織成四個層次，循序漸進地發展學生的創造力。同時，把S.W.E.E.T.I.E.教學法貫穿於所有工程設計，從情境引入到發現問題，再進行設計和搭建，以鞏固、優化和拓展結束。這樣的設計保證了每一次活動實施的質素和效率。本課程總共有8個單元，40餘個核心活動相互關聯，每個活動約1小時。通過40小時的探索實踐，學生可以完整地體驗人類工業文明的發展歷程和創新智慧。近年來，通過結合先進教學思想和現代教育技術，思維奇工程設計課程從線上轉化為線上線下混合式教學模式，極大地減少了實施STEM教育的難度。這混合式STEM課程深受中小學老師的歡迎，目前已經在香港60餘所中小學推行。本工作坊將讓老師完整體驗SWEETIE混合式工程設計課程的教學過程，並將著重討論實施過程的要點。通過此工作坊，老師可以增加對工程設計的理解，為實施新科學課科做好準備。

## Details of Parallel Session 1

3 January 2025 | 11:15-12:15

### 1.1 AI in Science Education [B4-LP-09]

Project-Based Learning with Artificial Intelligence as a Project Topic: Differences in Student Collaboration and Learning Experiences  
**Edwin Chng, Yong Leng Kelvin Tan and Aik Ling Tan** (paper ID: 31)

AI vs Teachers — A Comparative Study between Man and Machine Based on Teaching Design of Biology in Senior High School  
**Jian Yu, Wenxuan Ji** (paper ID: 47)

The Role of ChatGPT and Teachers in Developing Students' Models: Insights from an Awarded Elementary Science Fair Project  
**Chen-Yu Chen, Jian-Yi Lin and Jing-Wen Lin** (paper ID: 115)

### 2.1 Comparative Research of Science Curriculum [B4-LP-08]

Analogical Reasoning in Physics Textbooks: An International Comparative  
**Chih-Hao Chen, Chi-Hong Kuok, Jian-Xin Yao** (paper ID: 129)

A Comparative Study of Science Textbook Exercises in the Guangdong-Hong Kong-Macao Greater Bay Area from the Perspective of PISA 2025 — Taking High School Biology Textbooks of the People's Education Edition and the Oxford Edition as Examples  
**Xiangsheng Dai, Wang Qi and Yanyan Wei** (paper ID: 13)

A Curriculum Content Mapping Analysis of Chinese Compulsory Education Biology Curriculum Standards: Insights from the OECD Education 2030 Perspective  
**Shan Lin, Xiaorong Li, Xingdong Tang, Chang Sun, Mingxia Tan, Tian Luo and Jian Wang** (paper ID: 38)

### 3.1 Developing & Accessing STEM Creativity [D2-LP-10]

Is STEAM really better than STEM? Evidence from a product-design creativity test  
**Xinfa Yi, Yao Yu and Zheng Wang** (paper ID: 18)

Technology and Engineering Education in Chinese secondary schools: Objective, Formation and Future  
**Youwei Yang, Jianjun Gub** (paper ID: 106)

Engaging Students in Troubleshooting in STEM Project Based Learning  
**Mei Yu Lin, Vincent Tse, Tze Chung Lam, Chi Tuen Fung, Shuk Yee Ng** (paper ID: 37)

### 4.1 Creative Problem-Solving in Science Classroom [D2-LP-09]

Investigating problem-solving approaches in science assessments among high school science and regular class students  
**Hui Luan, Lei Bao and Chun-Yen Chang** (paper ID: 53)

Utilization of Process Data in China: Exploring Students' Problem-solving Strategies in Computer-based Science Assessment Featuring Interactive Tasks  
**Pingping Zhao, Chun-Yen Chang, Yueyang Shao, Zhi Liu, Hao Zhou and Jian Liu** (paper ID: 17)

知識結構與執行能力驅動創造力：思維型教學對於小學生科學創新素養的影響  
**Zheng Wang, Xinfa Yi** (paper ID: 8)

### 5.1 Implementation of Project-Based Science Learning [D1-LP-08]

The Structure, Influencing Factors, and Enhancement Strategies of Project-Based Teaching Competence of Secondary Physics Teachers  
**Yangping Zhou, Jiaqi Liu, Ruicheng Sha and Chunmi Li** (paper ID: 29)

Designing Solutions in Middle School Science: A Multi-Case Study of the "Design and Construction of the Space Station Atmospheric Revitalization Subsystem" Project  
**Mingchun Huang, Lei Wang, Peng He and Weizhen Wang** (paper ID: 30)

Case Study of Project-based Teaching in Elementary Science under the Perspective of Productive Failure  
**Wang Xiaoteng, Fan Shi and Mingxia Zhang** (paper ID: 33)

## Details of Parallel Session 2

3 January 2025 | 15:45-16:45

**1.2 Eye-Tracking Research in Science Education [B4-LP-09]**

Utilizing Machine Learning for Intelligent of Scientific Creativity: Leveraging Scientific Knowledge Structure and Eye-Tracking Cognitive-Behavioral Data

**Yangping Li, Yang Zhang, Ruizhen Xi, Tingting Xuan, Weiping Hu** (paper ID: 134)

From Novice to Expert: Cognitive Mechanism of Scientific learning: Evidence from Negative Priming Paradigms and Eye Movements

**Shaona Zhou, Yushan Xiong, Zhong Yi** (paper ID: 78)

The effect of competitive environment on students' physics problem-solving: An eye-tracking study

**Qiuye Li, Yi Zhong, Sihang Liang, Yongxuan Li, Yifeng Ou, Shaona Zhou and Xianqiu Wu** (paper ID: 90)

**2.2 Cognitive Development in Science Education [B4-LP-08]**

Exploring Chinese Primary School Science Teachers' Beliefs, and Practice When Implementing Critical Thinking and Creative thinking

**Yani Wu, Sally Birdsall and Kirsten Locke** (paper ID: 51)

Inhibiting Specific Misconception or General Intuitive Rule? An Experimental Study on Inhibition of Misconceptions through Multiple Representations of Electric Field

**Yue Ming, Leheng Huang, Dean Li, Lei Bao, Keke Yu and Yang Xiao** (paper ID: 91)

Pupils' conceptions about animal ethics Based on Conceptual Metaphor Analysis

**Junmin Wang, Yajuan Hu** (paper ID: 23)

**3.2 STEM Attitude and Career [D2-LP-10]**

Promoting Gifted Students' STEM Career Perceptions and Interest involving Instruction by Educators and STEM Professionals

**Tian Luo, Winnie Wing-Mui So, Yu Chen, Zeyu Han and Yixuan Wang** (paper ID: 35)

促進青少年科學職業理想培養的跨學科課程建設研究

**王寧, Aik-Ling Tan, 胡衛平** (paper ID: 113)

Navigating Career Development Challenges for STEM Students: The need for a new comprehensive theory

**Lawrence P. W. Wong** (paper ID: 145)

鄉村小學科普現狀及協同機製研究——以肇慶市德慶地區為例

**Qianwen He** (paper ID: 146)

**4.2 Cultivation Creativity through Science Education [D2-LP-09]**

物理師範生創新能力培養路徑與實踐探索

**Hongyang Zhang and Changxing Yang** (paper ID: 85)

科學課程中教學策略提升創造力的元分析

**Yuanjing Lyu, Shuoqi Xiang, Zexuan Jiang and Weiping Hu** (paper ID: 142)

依托國家戰略科技力量培養青少年科技創新後備人才：武漢光電國家研究中心的案例研究

**Haiqin Yu, Jianyi Li (online)** (paper ID: 70)

**5.2 Science Teachers [D1-LP-08]**

Divergent Perspectives: Taiwan's Teacher Educators and Elementary Teachers' Views on Pre-Service Teachers' Bilingual Science Micro-Teaching Performance

**Jing-Yi Liu, Jing-Wen Lin and Hong-Wen Cheng** (paper ID: 6)

Examining Teacher Noticing: Insights into the Interplay with Motivation, Attitudes, Knowledge, and Skills among Pre-service Teachers with differing experience levels

**Jingxian Wang, Dineke Tigelaar, Shirong Nie, Yuheng Yang and Wilfried Admiraal** (paper ID: 140)

The Impact of Using the High School Chemistry Textbooks (2019 Edition) on Teachers and Students: A Structural Equation Modeling Approach

**Fangfang Li, Lei Wang** (paper ID: 75)

Measuring the validity of the pedagogical content knowledge (PCK) framework for inservice chemistry teachers

**Feng Deng, Wanrong Lan and Xiaogang Hu** (paper ID: 44)

## Details of Parallel Session 3

4 January 2025 | 10:00-11:00

### 1.3 Nature of Science [B4-LP-04]

Acquisition and retention of nature of science understandings: A five-year longitudinal study with Elementary Students  
**Chang Liu, Rui Liu, Jinjie Zhang and Peng He** (paper ID: 16)

An Empirical Research on the Interplay among Science Teachers' Epistemological Belief, Professional Identity and Digital Literacy  
**Han Chi, Wang hongyan** (paper ID: 62)

Research on the Presentation Characteristics of the Spirit of Collaboration among Scientists in High School Chemistry Textbooks  
**Jiangshan Liu, Yang Deng** (paper ID: 97)

### 2.3 Science Textbooks [D2-LP-08]

Using the Lens of Essential Questions-Perspectives to Investigate the Representations of Chemical Thinking in Chinese Secondary Chemistry Textbooks  
**Ming Chi, Changlong Zheng** (paper ID: 56)

How energy is conceptualized in the primary science textbooks from Finland and China  
**Yan Wang, Jari Lavonen** (paper ID: 101)

Visual representations of chemical bonding in China's high school chemistry textbooks over the past six decades  
**Ying Sun (online), Huilei Han** (paper ID: 109)

### 3.3 Exploring the Effects of STEM Learning [D2-LP-10]

Unleashing the potential of animated video-watching for fostering pupils' STEM career interests: A mixed-method study  
**Zeyu Han, Wing Mui Winnie So, Yu Chen and Wai Chin Li** (paper ID: 12)

Research on the influence of social-scientific issues learning (SSI-L) on students' dialectical thinking  
**Ronghua Zhang, Qingqing Ji** (paper ID: 86)

Exploring Classroom Activity Experiences and Their Impact on Students' Academic Achievement in Primary School Technology and Engineering: Insights from Mainland China  
**Binbin Cai and Cheng Liu** (paper ID: 105)

### 4.3 Identity in Project-Based Science Learning [D2-LP-09]

Cultivation of Middle School Students' Science Identity through Project-Based Learning of Physics  
**Jiaqi Liu, Yangping Zhou and Chunmi Li** (paper ID: 52)

A Study of Project-Based Curriculum to Promote Chemistry Identity among Junior High School Students with Different Family Science Capital  
**Lingyun Yuan, Yang Deng** (paper ID: 96)

Exploring the Formation of High School Students' Science Identity: A Qualitative Study  
**Sitong Chen, Changchun Lin** (paper ID: 137)

### 5.3 Innovative Science Teaching [D1-LP-08]

Scientific Teaching Research Based on Kuhn's Paradigm Theory -- Taking "phlogiston" as an example  
**Shang Dou** (paper ID: 69)

Exploring Sleep Education for Adolescents through the 7E Model: Insights from a Mixed Methods Study  
**Zhan Shi, Yingzhi Zhang** (paper ID: 49)

(遊)戲如人生: 透過桌遊行為分析永續發展議題表現之關聯研究  
**Ping-Han Cheng** (paper ID: 48)

## Details of Parallel Session 4

4 January 2025 | 11:15-12:15

**1.4 AI in Science Education [B4-LP-04]**

Enhancing Artificial Intelligence Precision and Implement Personalized Teaching in Science Education: Constructing a Science Knowledge Graph

**Zijian Yuan, Xipei Guo and Weiping Hu** (paper ID: 118)

運用Bloom's Taxonomy理論探討AI人工智慧應用於運動按摩之學習成效

**楊文仲, 黃琴扉** (paper ID: 110)

構建人工智能時代下的科學教材體系：挑戰、現狀與研發策略

**Junxia Zhang (online), Haiying Wang and Zhongxue Liu** (paper ID: 95)

**2.4 Science Curriculum Development and Implementation [D2-LP-08]**

New era primary school science education and its implementation path innovation research report

**Ziquan Zhong** (paper ID: 84)

The Current Status and Challenges of Promoting Ocean Literacy Education: A Qualitative Study on Teachers' Experiences

**楊貴蘭, 洪振方, 賴芃儒** (paper ID: 141)

偏遠地區開展化學項目式學習的困境的敘事研究

**Yanning Huang (online), Zeshuo Du** (paper ID: 125)

**3.4 STEM Attitude and Career [D2-LP-10]**

STEM capital-building in secondary school and students' STEM identity and career aspiration development

**Yu Chen, Wing Mui Winnie So and Jingsheng Jin** (paper ID: 10)

The role of pre-questions and feedback in learning engagement in STEM: the moderating effect of prior knowledge

**Qian Huangfu and Hong Pan** (paper ID: 80)

透過「科學探究競賽—這樣教我就懂競賽」資料分析 探討學習者參與科普競賽之動機

**黃琴扉, 蔣振宇, 陳綠子** (paper ID: 45)

**4.4 Higher-Order Thinking in Science Education [D2-LP-09]**

On the productivity of mechanistic reasoning in elementary science classroom

**Xiaowei Tang** (paper ID: 144)

Fostering Creativity: A Qualitative Analysis of Latest High School Chemistry Curriculum Standards in East Asia

**Fangfang Li, Jin Shen and Lei Wang** (paper ID: 76)

社會科學問題背景下中小學生的科學推理論證能力發展現狀：綜合結構性與批判性視角

**Xipei Guo, Xuemin Hao, Xin Ji, Weiping Hu** (paper ID: 41)

Research Progress and Prospect of Scientific Higher-order Thinking

**Huanxia Wang (online)** (paper ID: 112)

**5.4 Development of Assessment Tools [D1-LP-08]**

Developing and Validating an assessment tool of social responsibility in biology (ATSRB)

**Qian Hui Ge, Qun Xie** (paper ID: 24)

Research on the Development and Application of an Evaluation Tool for Junior High School Students' Chemical Science Practical Abilities

**Lu Li and Chuan Li** (paper ID: 131)

Science capital role in elementary school students' aspiration for science career

**Kuay-Keng Yang (online), Ming-Chao Lin and Sheau-Wen Lin** (paper ID: 135)

## Details of Parallel Session 5

4 January 2025 | 13:30-14:30

**1.5 Nature of Science, Socio-Scientific Issue and Inquiry [B4-LP-04]**

Model Content in Elementary and Middle School Science Textbooks: A Comparison with Students' Understanding  
**Chin-Cheng Chou, Mei-Hung Chiu** (paper ID: 149)

The Impact of Socio-Scientific Issue Web Searches on Sixth Graders' Scientific Epistemic Beliefs: Exploring the Interaction between Prior Beliefs and Information Positions  
**Jing-Wen Lin** (paper ID: 102)

Exploring Inquiry-Based Science Teaching in English-Medium Instruction (EMI) Classrooms in China: A Study on Teachers' Understanding, Perceptions, and Practices  
**Chaoqun Lu** (paper ID: 9)

**2.5 Science Curriculum Implementation [D2-LP-08]**

基於對分課堂教學模式的通識教育核心課程實踐  
**Cui Xiaxuan, Ma Shihong, Zhang Xuexin** (paper ID: 26)

融入科學教育的中學學科「三原色」課程資源開發框架與實施路徑  
**Xiaomin Zhong** (paper ID: 68)

中學綜合科學課程實施現狀調查研究  
**Lei Fu (online)** (paper ID: 55)

**3.5 Exploring the Effects of STEM Learning [D2-LP-10]**

Effects of Reverse Engineering as a STEM Pedagogy: A Meta-analysis  
**Luyao Hou, Zhihong Wan** (paper ID: 14)

A pilot study of primary school students' learning outcomes in STEM education in Shandong Province, China  
**Feiyue Wang, Tang Wee Teo and Shoubao Gao** (paper ID: 65)

大學生STEM小組互動量表之發展  
**Fen-May Chou (online), Hsiao-S-Lin Tuan and Chi-Chin Chin** (paper ID: 151)

**4.5 Affective Domains of Science Learning [D2-LP-09]**

Facial Expression Recognition for Probing Students' Emotional Engagement in Science Learning  
**Xiaoyu Tang, Yayun Gong, Yang Xiao and Lei Bao** (paper ID: 3)

Rural Students' Engagement with Science: An Empirical Analysis with the ASPIRES Framework  
**Ye Cao, Junqing Zhai** (paper ID: 21)

Gender Differences in Middle School Students' Multidimensional Science Learning Self-Efficacy and Its Sources in Mainland China  
**Binbin Cai and Cheng Liu** (paper ID: 107)

**5.5 Innovative Science Teaching [D1-LP-08]**

PISA視角下指向科學素養培育的中學地理教學路徑分析  
**Lidong Liu, Xiaomin Zhong** (paper ID: 64)

基於系統思維培養師範生科學提問能力的策略研究  
**Xiaoyang Gong, Lulu Li, Yujie Dang and Rui Wei** (paper ID: 43)

Interdisciplinary Physics Instruction in the Context of Social Media-Driven Socially-Acute Questions: Strategies for Enhancing Conceptual and Reasoning Skills  
**Zengze Liu, Zhifang Sang, Yuqing Hou, Youye Ding and Sudong Pan** (paper ID: 22)

## Details of Parallel Session 6

4 January 2025 | 14:30-15:30

**1.6 IT-Enhanced Science Learning [B4-LP-04]**

Enhancing Experimental Physics Instruction Using Digital Technology: A More Intuitive Approach to Electromagnetic Damping  
**Aqi Pan, Jin Tao, Xiaoyan Zhu and Hailin Mao** (paper ID: 83)

How is the impact of ICT-assisted experimental activity on students' physics learning: A meta-analysis of K-12 research  
**Yun Sun, Leyao Jiang, Jingqi Zou and Jiawei Song** (paper ID: 87)

利用腦波EEG分析探討VR融入教學對中學生注意力及學習成效的影響  
**Huang Chin Fei, Hsu Hsiu-Kuei (online)** (paper ID: 20)

**2.6 Developing and Evaluating Science Curriculum [D2-LP-08]**

Ignorance as Drivers of Inquiry: A Theoretical Framework for Evaluating Science Textbooks  
**Guanzhong Ma and Yichen Zhou** (paper ID: 117)

基於證據的教材微觀分析方法 —— 理解教材、用好教材的方法論  
**Yunbao Chen (online)** (paper ID: 127)

構建小學科學課程中的社會責任內容框架  
**Min Li, Weiping Hu** (paper ID: 39)

**3.6 Cross-Disciplinary Learning [D2-LP-10]**

Investigation On the Enhancement of Scientific Creativity in Students through STEAM-Based Courses  
**Chin-Fei Huang, Ssu-Wei Chang** (paper ID: 11)

基於核心概念的思維型跨學科科學實踐課程設計與實施  
**季鑫, 郭習佩, 胡衛平** (paper ID: 104)

基於大觀念的初中科學類學科跨學科主題學習課程建設研究  
**馮春艷** (paper ID: 15)

**4.6 Higher-Order Thinking in Science Education [D2-LP-09]**

Role of critical thinking in inductive reasoning under the context of scientific experiment: evidence from the event-related potentials  
**Haiqiong Zhu, Tong Li, Diwei Lian, Yunjie Ni, Hanqiu Yu, Yixi Guo, Siting Chen, Lei Bao, Keke Yu and Yang Xiao** (paper ID: 100)

Does Stress Hinder Creativity? Cognitive Neural Mechanisms and Neuromodulatory Interventions of Stress Affecting Creativity  
**Haijun Duan, Yifan Wang, Jiaqi Dang, Wanyi Li and Wenjuan Fu** (paper ID: 116)

SCPO教學提升高中生化學風險認知的實證研究  
**Liying Zhu (online), Chenyang Cui** (paper ID: 63)

**5.6 Science Teachers' PCK [D1-LP-08]**

以自製創新儀器和做中學為載體的科學教師一體化培養探索  
**袁令民, 閻從華** (paper ID: 156)

共同體 PCK能否促進個體PCK? 以職前物理教師「力與運動」主題下的學生知識為例  
**楊瀾, 包雷, 肖洋** (paper ID: 60)

中學物理教師隱性知識獲取對教研共同體教學創新影響機製與實踐路徑研究  
**李富強 (online), 高倩** (paper ID: 46)

## Details of Parallel Session 7

4 January 2025 | 16:00-17:00

### 1.7 Science Learning Process [B4-LP-04]

Defining Conceptual Understanding: A Three-Stage Model Using Generative Learning Theory Combined with Dynamic Binding Approach

**Shanshan Lu** (paper ID: 54)

A Moderated Model of Socio-Economic Status, Peer Relationships, and Science Performance among Primary and Middle School Students

**Zhi Liu, Jian Liu and Tian Xue Cui** (paper ID: 67)

Extending Theory of Planned Behavior Model: the importance of habits and traditional culture in influencing student's physics in-class silence behavior

**Yushan Xiong, Shaorui Xu, Qiuye Li, Xiaotong Cui, Shaona Zhou** (paper ID: 89)

Promoting Students' Issues-Based Learning through Navigating Uncertainty

**Jing Lin** (paper ID: 103)

### 2.7 International Perspectives on Science Teaching [D2-LP-08]

中國大陸和馬來西亞在職教師教學信念對比研究

**陳笑鵬, 魏銳, 王磊** (paper ID: 32)

Research on Teachers' Instructional Support in Kindergarten Science Picture Book Teaching Activities —— Based on CLASS Classroom Evaluation System

**Nini Zhang and Zhaowei Liu** (paper ID: 123)

Identifying the Blind Spot of Lack of Ecological Perspective and Strategies to Relieve It: An Example of Public Dumping of Milk

**Yujing Guo** (paper ID: 73)

### 3.7 Assessing Science Learning [D2-LP-10]

Construction of Performance Measurement Model for Secondary School Students' Scientific Explanation Ability

**Haoyu Huang, Yayun Gong and Xiaoyu Tang** (paper ID: 4)

Design and Implementation of Narrative Assessment in Primary School Science Education under the Framework of Core Competencies

**Mingxia Zhang, Fan Shi and Xiaoteng Wang** (paper ID: 36)

中學生化學學習表徵能力的測評研究

**Yanxia Jiang(online), Haiyan Wang** (paper ID: 34)

### 4.7 STEM Learning [D1-LP-09]

Designing AI enabled STEM Learning Platform for Primary School Students

**Jingxi Liu and Daner Sun** (paper ID: 136)

An Analysis of the Tendency and Influence Factors of Preservice Teachers Integrating Artificial Intelligence into STEM Education

**Fan Yanhua, Sun Fengyao and Sun Nianke** (paper ID: 154)

Teaching design of junior high school physics unit review based on project-based learning —— Take the "Lens and its Application" unit of the Human Education Edition as an example

**Yujie Gui** (paper ID: 120)

5.7 Review of Research (Session Details Continued on Next Page →)

**Details of Parallel Session 7***4 January 2025 | 16:00-17:00***5.7 Review of Research [DI-LP-08]**

ICT-assisted experiments in K-12 science education: a systematic literature review

**Leyao Jiang, Yun Sun, Shuting Zhu and Jiawei Song** (paper ID: 88)

Mapping research on International Educational Science Research by Chinese mainland scholars: A bibliometric review of the literature in the last 20 years

**李雪, Weiping Hu** (paper ID: 79)

基於館校結合的區域性科學教育質量提升路徑研究

**Huijun Wang, Xi Kong** (paper ID: 94)

The Structure of Engineering Literacy and Its Educational Objectives in Compulsory Education

**Lan Wang, Shiman Huang and Shouyin Liu** (paper ID: 148)

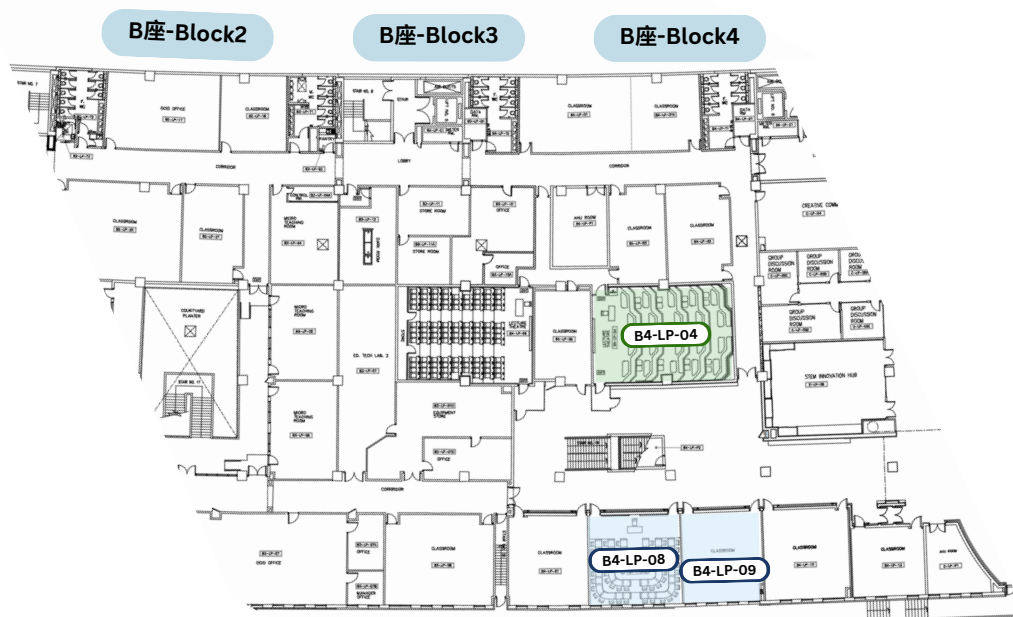
# 會議場地地圖 Venue Map

The Education University of Hong Kong  
Tai Po Campus  
香港教育大學大埔校園



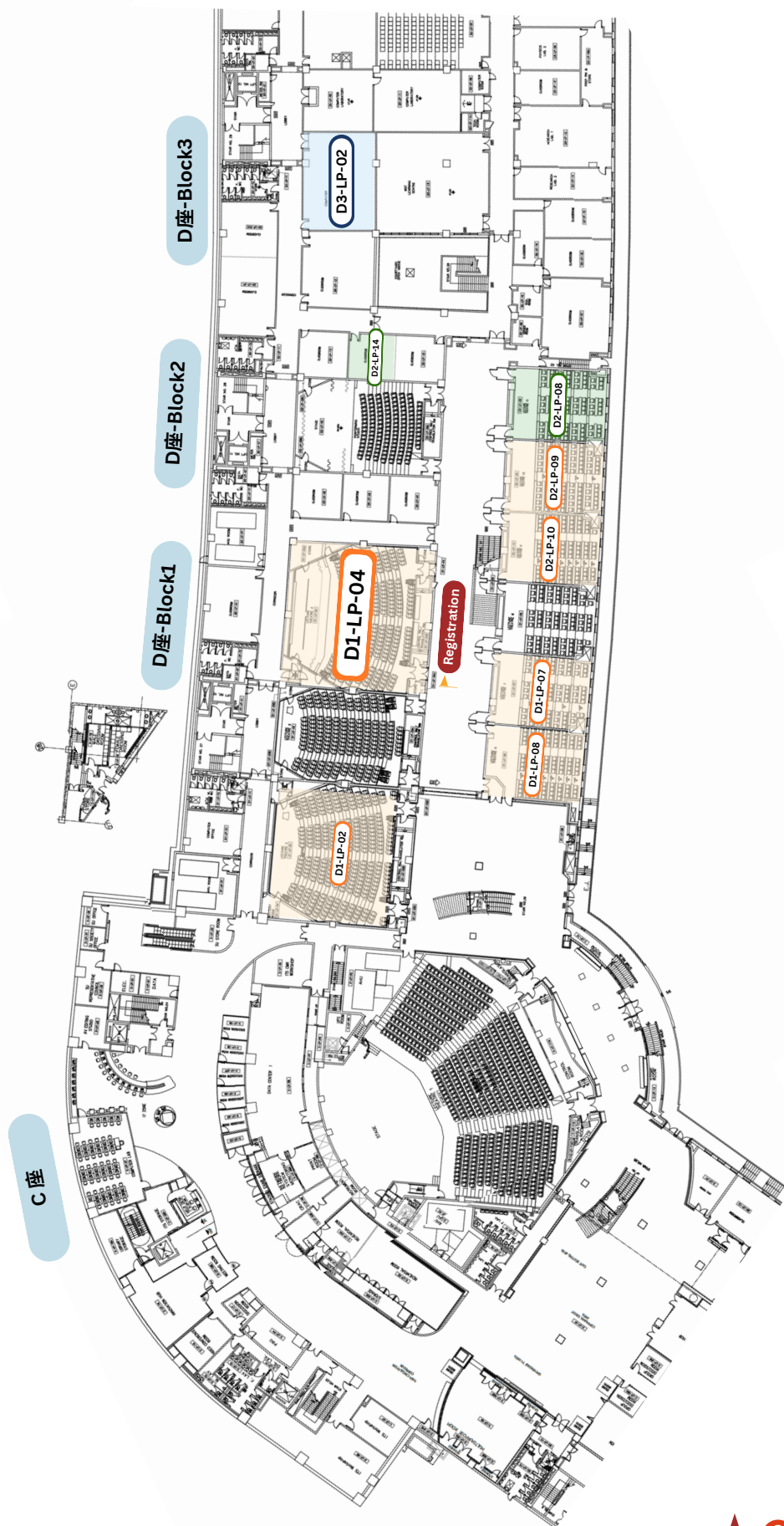
**NOTE:** 會議場地主要分佈在BLOCK B和BLOCK D. Conference venues are mainly located in BLOCK B and BLOCK D.

- ★ 1 Taxi/Bus 的士站/巴士站
- ★ 3 B-Academic Building South Wing B座-教學大樓南翼
- ★ 2 Pedestrian Entrance 行人入口
- ★ 4 D-Academic Building North Wing D座-教學大樓北翼
- ★ 5 C-Central Facilities Building And Mong Man Wai Library C座-中央大樓及蒙民偉圖書館



★ B-Academic Building South Wing  
B座-教學大樓南翼

# 會議場地地圖 Conference Venue Map



# 會議交通安排 Transportation Arrangements



## 地址:

香港新界大埔露屏路十號

## Address:

10 Lo Ping Road, Tai Po, New Territories, Hong Kong



## 公共交通:

- 九巴74K巴士來往港鐵大埔墟站及三門仔途經教大（中午12時前，從大埔墟站先到香港教育大學；中午12時後，先往三門仔再到香港教育大學）
- 公共專線小巴26號來往大埔校園及馬鞍山海柏花園
- 公共專線小巴26A號輔助線，往來大埔校園至大埔元洲仔（循環線），服務時間週一至五每日上午7:30至9:30以及下午5:30至8:30

## Public Transport:

- KMB No. 74K from Tai Po Market MTR Station to Sam Mun Tsai via Tai Po Campus (before 12:00 n.n. the bus will call at Tai Po Campus and after 12:00 n.n. will go to Sam Mun Tsai first before calling at Tai Po Campus)
- Green Minibus No. 26 from Tai Po Campus to Bayshore Towers, Ma On Shan and vice versa
- Green Minibus No. 26A from Tai Po Campus to Yuen Chau Tsai, Tai Po circular service (7:30 am to 9:30 am & 5:30 pm to 8:30 pm, Monday through Friday)



## 會議穿梭巴士服務★:

- 會議穿梭巴士來往大埔校園及港鐵大學站

## Shuttle Bus Services★:

- Shuttle Bus from Tai Po Campus to University MTR Station and vice versa

### 3 January 2025 (Friday)

### 4 January 2025 (Saturday)

#### Time

University MTR Station --> EdUHK Tai Po Campus  
- Departure Time: 8:00am, 8:10am, 8:20am & 8:30am

EdUHK Tai Po Campus --> University MTR Station  
- Departure Time: 5:50pm, 6:00pm, 6:10pm & 6:20pm

University MTR Station --> EdUHK Tai Po Campus  
- Departure Time: 8:00am, 8:10am, 8:20am & 8:30am

EdUHK Tai Po Campus --> University MTR Station  
- Departure Time: 5:50pm, 6:05pm

EdUHK Tai Po Campus --> ClubONE The Grand  
(12 Science Park West Avenue, Science Park)  
- Departure Time: 5:50pm, 6:00pm

ClubONE The Grand (Science Park) --> University MTR Station  
- Departure Time: 9:30pm, 9:35pm

# 組織委員會 Organising Committee

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## Abstracts of Parallel Session 1

### 1.1 AI in Science Education [B4-LP-09]

3 January 2025 | 11:15-12:15

#### **Project-Based Learning with Artificial Intelligence as a Project Topic: Differences in Student Collaboration and Learning Experiences (paper ID: 31)**

Edwin Chng (National Institute of Education), Yong Leng Kelvin Tan (Hwa Chong Institution) and Aik Ling Tan (National Institute of Education)

**Keywords:** Project-based learning, Student collaboration, 21st-century digital skills, Cultural historical activity theory (CHAT), Qualitative methods, Secondary student

**Abstract:** Project-based learning (PBL) generally involves students collaborating in a contemporaneous manner to resolve authentic problems with tangible materials. In recent years, the advent and rise of artificial intelligence (AI) technologies offers educators the possibility of bringing PBL into digital domains, where students can work asynchronously with virtual materials to tackle significant issues. Additionally, adopting AI as a topic in PBL affords educators the opportunity to develop students' 21st-century digital skills, together with their digital literacy. Yet, the altered nature of PBL with AI as a project topic is unexamined. In particular, the impact of working digitally and asynchronously on student collaboration and learning experiences is unexplored. To this end, we studied two groups of secondary school students (n=6) who went through PBL with AI as a theme in their projects. Employing cultural historical activity theory (CHAT) as a theoretical lens, we qualitatively analysed collected interviews and reflections to unpack their collective collaboration and learning experiences. Results indicate that because of the high demand for background knowledge when working with AI technologies, learning experiences diverge remarkably for novices and experts, and collaboration dynamics can be upended as an unintended consequence. Our research findings demonstrate that educators ought to reconsider their facilitation approach when the nature of PBL changes, and we provide recommendations for supporting students in PBL with AI as a project topic.

#### **AI vs Teachers — A Comparative Study between Man and Machine Based on Teaching Design of Biology in Senior High School (paper ID: 47)**

Jian Yu (Hebei Normal University) and Wenxuan Ji (Hebei Normal University).

**Keywords:** High school, Empirical research, AI, Instructional design, Biology

**Abstract:** The significance of AI in the field of education has gradually emerged. It has begun to help teachers complete many tasks, including writing instructional design, searching and sorting out materials, making PPT, assisting teaching, etc. Its ability is also constantly developing and iterating. Taking the learning content of "Examples of Material Transmembrane Transport" in China High School as an example, Chat GPT, Kimi and Huo Xing of iFLYTEK were trained to write three AI instructional designs, and the real instructional designs of three teachers in different parts of China were compared. Five experienced judges graded according to the standards and wrote comments. The results show that: (1) the ranking of AI instructional design is lower than that of teachers' instructional design, with a range of 7.6 (out of 100 points), with a small difference in total scores; (2) the average correct rate of AI instructional design can be identified is 67%, and only one judge accurately identified three AI instructional designs; (3) among the seven dimensions of instructional design evaluation, the average level of AI instructional design is higher than that of teachers in the dimension of "extended design" and one AI instructional design is higher than that of two teachers in the dimension of "design innovation"; (4) most judges think that there are some problems in AI instructional design, such as outdated teaching content, solidified logic and weak pertinence. This study puts forward some suggestions on the strategies of AI supporting teachers' instructional design writing.

#### **The Role of ChatGPT and Teachers in Developing Students' Models: Insights from an Awarded Elementary Science Fair Project (paper ID: 115)**

Chen-Yu Chen (National Taipei University of Education), Jian-Yi Lin (National Taipei University of Education) and Jing-Wen Lin (National Taipei University of Education)

**Keywords:** Elementary school, qualitative analysis, Models, Modeling, ChatGPT

**Abstract:** This study examines the evolution of scientific models in a primary school science fair team collaborating with ChatGPT, focusing on how teachers and ChatGPT facilitate this process. Using a case study approach, the research centers on a top-ranking Taiwanese team composed of two students and two teachers who integrated ChatGPT into their project to construct an optimal evacuation route model. The study utilizes Boulter & Buckley's (2000) model classification framework and Biggs & Collis's (1982) SOLO taxonomy to analyze graphical representations from the students' modeling efforts. The Model-Based Inquiry (MBI) framework describes the modeling process, categorizing teaching transcripts and dialogue records, with an inter-rater reliability of 0.91. The modeling process evolved through distinct stages. Initially, teachers guided the development of Level 1-2 Scale models. As students grasped complex information, they modified model representations through interactions with ChatGPT and teachers. After two revision cycles, they advanced to Level 3 Maps models, demonstrating multiple relationships. In the final evaluation stage, teacher guidance diminished, allowing students to use ChatGPT independently to create Level 4 Computational and Concept-process models. The results indicate a shift from teacher-led instruction to ChatGPT-based self-inquiry (50-100%), showcasing students' improved skills in interpreting ChatGPT outputs and developing diverse scientific models. This research highlights the potential of AI collaboration in enhancing modeling skills and promoting autonomous learning in science education.

## Abstracts of Parallel Session 1

### 2.1 Comparative Research of Science Curriculum [B4-LP-08]

3 January 2025 | 11:15-12:15

#### Analogical Reasoning in Physics Textbooks: An International Comparative (paper ID: 129)

Chih-Hao Chen (Beijing Normal University), Chi-Hong Kuok (Beijing Normal University) and Jian-Xin Yao (Beijing Normal University)

**Keywords:** Analogical Reasoning, Physics Education, Physics Textbooks, High School, Quantitative Research

**Abstract:** Analogical reasoning serves not only as a teaching strategy that facilitates students' understanding of new knowledge through existing knowledge but also as an effective scientific thinking method in scientific discovery. To better cultivate students' analogical reasoning skills, this paper investigates the application of analogical reasoning in high school physics textbooks from China and the United States. Initially, the research identifies cases that align with the definition of analogical reasoning (Holyoak, 2012; Gentner, 1983; Vosniadou, 1989), followed by a feature analysis and an element analysis of these cases. The feature analysis framework is modified based on commonly used analogy classification scheme in science education (Orgill & Bodner, 2006), while the element analysis framework is derived from the research on the core elements of analogical reasoning in psychology (Holyoak, 2012; Vosniadou, 1989). Subsequently, a comparative analysis of the findings from the two sets of textbooks is conducted. The findings indicate that mechanics and electromagnetism are the domains in which analogical reasoning is most frequently applied. Chinese textbooks primarily choose textbook knowledge as sources, whereas U.S. textbooks draw equally from textbook and experiential knowledge. Both editions emphasize relational similarity in analogical relationships, predominantly employing verbal representations, yet they lack sufficient discussion of analogical methodology. Furthermore, deficiencies in essential elements are evident in analogies presented in both editions. Overall, while each edition displays distinct characteristics, the differences are minimal, and both have potential for improvement, such as enhancing methodological guidance and refining essential elements.

#### A Comparative Study of Science Textbook Exercises in the Guangdong-Hong Kong-Macao Greater Bay Area from the Perspective of PISA 2025 —Taking High School Biology Textbooks of the People's Education Edition and the Oxford Edition as Examples (paper ID: 13)

Xiangsheng Dai (17860610627), Wang Qi (17865561738) and Yanyan Wei (13977391376)

**Keywords:** PISA 2025, textbook exercises, scientific literacy, secondary education, mixed research methods

**Abstract:** Based on the PISA2025 scientific literacy assessment framework, an assessment system covering three dimensions of scientific situation, scientific knowledge, and scientific ability is constructed. The exercises in high school biology textbooks of the People's Education Edition and the Oxford Edition are deeply analyzed, and professional suggestions are put forward for the design and transformation of textbooks and exercises. The research finds that: (1) In the dimension of scientific situation, both versions of textbooks highly focus on "individual" and "global" contexts, while the involvement in "regional/national" scientific backgrounds is relatively less. (2) At the scientific knowledge level, both pay more attention to content knowledge, have the least involvement in procedural knowledge, and have different emphases on cognitive knowledge. (3) In terms of scientific ability, both focus on the dimension of "posing questions and explaining phenomena by scientific methods", while there are differences in the focuses on the other two dimensions. Through chi-square tests, it is concluded that the exercises of the two versions of textbooks show significant differences in all three dimensions. The following conclusions are drawn: (1) Increase exercises with "regional/national" scientific backgrounds to infiltrate patriotism education. (2) Strengthen the interdisciplinary connections of exercises to improve students' interdisciplinary literacy. (3) Strengthen the examination intensity of scientific inquiry ability in questions to cultivate students' comprehensive practical ability.

#### A Curriculum Content Mapping Analysis of Chinese Compulsory Education Biology Curriculum Standards: Insights from the OECD Education 2030 Perspective (paper ID: 38)

Shan Lin (College of Life Sciences, Beijing Normal University), Xiaorong Li (Faculty of Education, Beijing Normal University), Xingdong Tang (Faculty of Education, Beijing Normal University), Chang Sun (College of Life Sciences, Beijing Normal University), Mingxia Tan (College of Life Sciences, Beijing Normal University), Tina Luo (College of Teacher Education, Capital Normal University) and Jian Wang (College of Life Sciences, Beijing Normal University)

**Keywords:** Compulsory Education Biology Curriculum Standards, Biology education, Curriculum content mapping, OECD 2030, Quantitative Research

**Abstract:** Curriculum standards are critical to a nation's education system and directly impact talent development and overall national progress. The majority of studies on curriculum standards tend to focus on a single competency. This study aims to examine the extent to which the competencies outlined in the OECD 2030-oriented learning framework are represented in Chinese Compulsory Education Biology Curriculum Standards (CEBCS) as a whole and within individual content subjects. To achieve this, the study involved conducting a content analysis of the 2022 edition of the CEBCS for Grades 7-9 in China. A mapping grid was generated to reflect the relationship between the content subjects in the curriculum standards and the level of competency representation. The result indicates that the standards encompass 20 of the 28 competencies, focusing on foundational literacies, transformative competencies, and competency development. Certain competencies, such as Action, Literacy, and Problem-solving, were emphasized across content subjects, while others were uniquely emphasized within specific content subjects. This study provides a comprehensive view of China's grade 7 to grade 9 CEBCS from the perspective of future literacy development and can inform efforts to reform the curriculum. It also suggests designing curriculum standards at the upper level in light of the links between different disciplines, content subjects, and competency to enhance the future key competency of students.

## Abstracts of Parallel Session 1

### 3.1 Developing & Accessing STEM Creativity [D2-LP-10]

3 January 2025 | 11:15-12:15

#### Is STEAM really better than STEM? Evidence from a product-design creativity test (paper ID: 18)

Xinfa Yi (Key Laboratory of Modern Teaching Technology, Ministry of Education of China at Shaanxi Normal University), Yao Yu (Shude Primary School of Chengdu) and Zheng Wang (Key Laboratory of Modern Teaching Technology, Ministry of Education of China at Shaanxi Normal University)

**Keywords:** STEM and STEAM education, art education, creativity and innovation, educational assessment, China pedagogies contexts

**Abstract:** STEM education and STEAM education are the current trends in the development of creative talents. This article compares the differences between the two types of education, reviews implementation models in China, and identifies shortcomings and perceived biases in STEAM education. Inspired by existing research on learning, this article assesses students' ability to create apps, games, and other products by administering the Creativity Scientific Product Design Test (Hu & Adey, 2002) to students of different majors in four different pedagogical contexts. The originality, painting skills, and functionality of creative products in the picking machine products prove that art education in STEAM education is indeed superior to STEM education in fostering creativity. The approach taken to assess creativity focuses on students' autonomy in designing products and designs. Likewise, through our assessment, it was also found that gender differences affect performance in painting skills and originality, as well as the superiority of STEAM, only exists in the context of a combination of art education and STEM education. More so, this paper further emphasizes the necessity of STEAM education in the future, aiming to develop interdisciplinary talents from practice-related disciplines. We encourage that pedagogical objectives and assessment methods that combine knowledge and practical techniques should be adopted. The search for relatively superior time models based on the present STEAM education model is a promising opportunity.

#### Technology and Engineering Education in Chinese secondary schools: Objective, Formation and Future (paper ID: 106)

Youwei Yang (+8613013978424) and Jianjun Gu (+8613013978424)

**Keywords:** Technology and engineering education, STEM, Current situation, Future courses, Chinese education, Theoretical, Secondary student

**Abstract:** Although technological and engineering literacy are considered one of the important components of the 21st century competencies, and technology and engineering play a significant role in STEM education, technology and engineering education is still seen as a missing link in K-12 STEM education. In this context, this study, combined with preliminary research findings, analyzes several forms of technology and engineering education received by Chinese secondary school students, various objectives of secondary schools in carrying out technology and engineering education, and discusses several key issues in the future Chinese secondary school technology and engineering curriculum, combining the perspectives of philosophy of science and technology. The research results show that: (i) secondary school technology and engineering education is usually carried out in the form of either separate courses, or integrated into science/other practical education; (ii) Most secondary schools carry out technology and engineering education for students to the preparation for exams, rather than to enhance literacy or acquire skills; and (iii) The content of Chinese secondary school technology and engineering courses will continue to focus on general knowledge and skills, with an increase in engineering trends. This study will systematically introduce the current situation and future of Chinese secondary school technology and engineering education, and these findings will be valuable for integrating technology and engineering education into science courses and promoting interdisciplinary STEM education.

#### Engaging Students in Troubleshooting in STEM Project Based Learning (paper ID: 37)

Mei Yu Lin (Po Leung Kuk Laws Foundation College), Vincent Tse (Po Leung Kuk Laws Foundation College), Tze Chung Lam (Po Leung Kuk Laws Foundation College), Chi Tuen Fung (Po Leung Kuk Laws Foundation College) and Shuk Yee Ng (Po Leung Kuk Laws Foundation College)

**Keywords:** Troubleshooting, Engineering cycle, Highschoolers, STEM education, Project-based learning

**Abstract:** Project-based Learning (PBL), an educational approach widely applicable in different fields of study, most notably STEM. PBL involves students working together on an authentic, and usually challenging problem or project, developing knowledge and skills in the process with minimal interference from teachers. PBL requires students to work together and analyze complex information, brainstorm plans and evaluate potential solutions for various situations. Students' cognitive and collaborative abilities can be enhanced, while providing experiences in information collection and developing alternative solutions. A group of highschoolers' project is to develop a test kit to detect and kill prostate cancer cells, competing in an international competition. With minimal guidance from teachers, this ambitious and demanding task poses challenging obstacles and setbacks. Using the engineering cycle to come up with a solution, it involves identifying the problem, conducting background research and using previous experiment data and notes. A prototype solution is then developed and tested. The students keep a detailed notebook on all aspects of the project encountered difficulties. With this sophisticated logbook system, they were able to quickly identify problems and adjust accordingly to get desired results. Each experiment the team performed had at least one additional team member acting as an observer, taking notes and ensuring that everything goes according to plan. The principles of PBL and engineering cycle, perform specialization and collaboration between team members to the highest degree possible. The learning journey of the students will be recorded and students have to do self-reflection after the task being completed.

## Abstracts of Parallel Session 1

### 4.1 Creative Problem-Solving in Science Classroom [D2-LP-09]

3 January 2025 | 11:15-12:15

#### Investigating problem-solving approaches in science assessments among high school science and regular class students (paper ID: 53)

Hui Luan (National Taiwan Normal University), Lei Bao (The Ohio State University) and Chun-Yen Chang (National Taiwan Normal University)

**Keywords:** problem-solving approaches in science assessments, high school students, qualitative interview

**Abstract:** Scientific thinking and reasoning skills have long been emphasized as core competencies for 21st century learners. Thus, assessing students' scientific thinking and reasoning abilities has become a critical area of research. However, how scientific reasoning skills are employed in the approaches and strategies that students use to solve problems in science assessments remain unclear. In this study, a total of 34 high school students participated in semi-structured interviews. Among them, 17 were in science classes and 17 in regular classes. Students were asked to explain their problem-solving approaches in two science assessments: three items from a high-stake examination on science content, the Comprehensive Assessment Program (CAP), and three items from a large-scale assessment on scientific reasoning, Inquiry in Scientific Thinking, Analytics, and Reasoning (iSTAR). Students were also asked to compare and contrast how they experienced and perceived CAP and iSTAR items. The results showed that students from both classes tended to adopt surface strategies for CAP problems but deep strategies for iSTAR problems. In addition, although students perceived school education as more helpful for CAP problems, students from both groups exhibited higher interest and self-efficacy for iSTAR problems. With respect to group differences, the findings revealed that students in science class outperformed students in regular class on both CAP and iSTAR items. In addition, science class students employed deep cognitive and metacognitive strategies more frequently than regular class students. Results from this study can reveal the strategies that students develop in solving different science problems and inform science teaching practices.

#### Utilization of Process Data in China: Exploring Students' Problem-solving Strategies in Computer-based Science Assessment Featuring Interactive Tasks (paper ID: 17)

Pingping Zhao (Beijing Normal University), Chun-Yen Chang (National Taiwan Normal University), Yueyang Shao (Beijing Normal University), Zhi Liu (Beijing Normal University), Hao Zhou (Beijing Normal University) and Jian Liu (Beijing Normal University)

**Keywords:** Process data, Scientific problem-solving, Computer-based assessment, China

**Abstract:** Students' problem-solving strategies and the differences among strategy groups were explored by analyzing the process data collected during student interactions with computer-based science items. Data were gathered from 1516 eleventh-grade students from 4 schools in China. Analyses of the sequences of students' response actions revealed that the students were divided into four strategy groups when designing experiments to solve scientific problems: the scientific and rigorous strategy (18.5%), scientific and less rigorous strategy (25.4%), incomplete strategy (31.5%), and chaotic strategy (24.6%). The heatmaps of response actions for each strategy and the frequencies of the most representative response sequences were further explored to understand the students' detailed trajectories. The results showed that successful problem solvers were generally inclined to explore all possibilities of experimental combinations and design experiments scientifically and rigorously based on the relevant scientific principles. Moreover, the timestamps of response actions were explored to show that the students who adopted the scientific and rigorous strategy spent more time seeking solutions, suggesting that students may need sufficient time to solve complex and authentic scientific problems. The findings enrich the literature on using process data to address theoretical issues in educational assessment and provide students with individualized instructional needs for teachers to improve students' scientific problem-solving competency.

#### 知識結構與執行能力驅動創造力：思維型教學對於小學生科學創新素養的影響 (paper ID: 8)

Zheng Wang (a Key Laboratory of Modern Teaching Technology (Ministry of Education), Shaanxi Normal University, Xi'an, P.R. China) and Xinfu Yi (a Key Laboratory of Modern Teaching Technology (Ministry of Education), Shaanxi Normal University, Xi'an, P.R. China)

**Keywords:** Creativity, Semantic Network, Cognitive Flexibility, school-age children, Quantitative Research

**Abstract:** 最新的認知網路科學與創造力研究表明，創造性思考的生成是由自下而上的聯想能力與自上而下的執行能力共同作用的結果。根據創造力聯想理論，語意知識結構透過聯想能力這個中介對創造性思考產生影響。然而，目前語意網絡建構方法的問題導致語意網絡結構的動態變化、執行加工過程與創造力之間的關係尚不清楚。本研究採用橫向與縱向結合的研究方法，對108名9至12歲小學生（女生44名，男生64名）的科學課程教學展開研究。透過橫向對比研究發現，與接受傳統科學教學的控制組相比，接受問題導向自主建構和思維訓練方法科學課的實驗組表現出更高效的語義網絡結構，高效的知識結構和高認知靈活性表現出更具優勢的創造力。隨後，在對控制組54名被試重複研究1的課程教學後，縱向對比研究發現，思維型教學顯著提升了受試者的語意網絡結構表現、聯想能力與創造力。更重要的是，在接受相同課程的條件下，具有較高認知彈性的受試者創造力的提升更為顯著。本研究不僅為雙因素創造力機制理論提供了新的實證證據，同時也揭示了一種更科學、更有效的培養中小學生科學創新素養的方法：自下而上的知識結構與自上而下的執行能力（認知彈性）的協同培養。研究結果對中小學師生科學教育實踐具有重要意義，能夠提供教師有效指導。

## Abstracts of Parallel Session 1

### 5.1 Implementation of Project-Based Science Learning [D1-LP-08]

3 January 2025 | 11:15-12:15

#### The Structure, Influencing Factors, and Enhancement Strategies of Project-Based Teaching Competence of Secondary Physics Teachers (paper ID: 29)

Yangping Zhou (Beijing Normal University), Jiaqi Liu (Beijing Normal University), Ruicheng Sha (Beijing Normal University) and Chunmi Li (Beijing Normal University)

**Keywords:** Secondary physics teachers, Project-Based Teaching Competence, Competence structure, Influencing factors, Enhancement strategies, Mixed methods research

**Abstract:** Project-based learning is a potent pedagogical method for the comprehensive development of students' core literacy in physics. While it is acknowledged that the Project-Based Teaching Competence (PBTC) of secondary physics teachers is pivotal for fostering high-quality project-based learning, the components and influencing factors of secondary physics teachers' PBTC remain underexplored. This deficiency potentially diminishes the applicability and efficacy of strategies intended to enhance secondary physics teachers' PBTC. To address this gap, our study constructed an 'iceberg structure' for the PBTC of secondary physics teachers, comprising three primary dimensions—personality traits, knowledge mastery, and teaching ability—and twelve secondary dimensions. We then developed and administered scales to measure these dimensions among physics teachers across three regions in China. Significance of difference tests were conducted on 223 teacher assessment data. The test results indicated that three factors at the individual level (i.e., years of teaching experience, experience in project-based teaching practice, and experience in seminars for improving project-based teaching) and three factors at the external environment level (i.e., school support, peer support, and expert support) would have significant effects on different primary and secondary dimensions of secondary physics teachers' PBTC, respectively. The findings led to the formulation of a five-point strategy for competence enhancement, focusing on the autonomous professional development of teachers and the optimization of the external teaching environment. This study offers valuable insights for educators and administrators aiming to enhance project-based learning in secondary physics education.

#### Designing Solutions in Middle School Science: A Multi-Case Study of the "Design and Construction of the Space Station Atmospheric Revitalization Subsystem" Project (paper ID: 30)

Mingchun Huang (Capital Normal University), Lei Wang (Beijing Normal University), Peng He (Washington State University) and Weizhen Wang (People's Education Press Curriculum and Textbook Research Institute)

**Keywords:** Designing Solutions, Middle school, A Multi-Case Study

**Abstract:** Although the worldwide K-12 science education highlights the need for integrating the core ideas in science and engineering practices (e.g., NGSS Lead States, 2013; Ministry of Education, P. R. China, 2017a; 2017b; 2017c), few studies have explored how do students perform design solutions when they experience the DBS project. To address this gap, this study uses the three component ideas of design solution in NGSS as a analytic framework and employs a multiple case study design (Stake, 2000) . In March to June 2024, 54 9th-grade students from a Beijing middle school designed and built a "Space Station Atmospheric Revitalization Subsystem" over 10 lessons, with 7 lessons for an oxygen generator and 3 for a carbon dioxide scrubber. The study employed a discourse-supported design-based approach for the project instruction(see Figure 1), The students were divided into nine groups and each group had six students. The findings showed that mine groups of students' design solutions demonstrated different patterns.(i) In defining and delimiting engineering problems, middle school students encounter three kinds: Demand-based, Technique-based, and Scientific principle-based. These problems range in complexity from static, qualitative issues to systemic, dynamic scenarios, with a focus on underlying scientific principles.(ii)In developing solutions to problems, they solved problems by considering the Demand, Technique, and Scientific principle in varying degrees of relevance.Accordingly, their problem-solving demonstrates differences in the length of solution paths. (iii) Students tend to select easy problems for quick resolution. Only problems involving systems thinking and regulation require multiple rounds of optimization. (iv)Students often abandon many ideas from the design to production phase, with problems requiring interdisciplinary problem-solving frequently being quickly given up on.The findings have implications for East Asian teachers to cultivate students' design solutions in design based interdisciplinary projects.

#### Case Study of Project-based Teaching in Elementary Science under the Perspective of Productive Failure (paper ID: 33)

Wang Xiaoteng (Qingdao university), Fan Shi (Qingdao university) and Mingxia Zhang (Qingdao university)

**Keywords:** Elementary Science, Productive failure, Project-based learning, Mixed Methods Study

**Abstract:** The study focuses on project-based studying in primary school science under the perspective of productive failure and explores how to advance the process of the project step by step with "failure" as a clue, to obtain the goal of cultivating students' scientific literacy. Based on the relevant literature, the study first proposed the design principles of project-based teaching in elementary science under the perspective of productive failure and the "2+6" teaching link. Afterward, a six-lesson quasi-experimental study was carried out on the project of "Homemade 'Hotter'" in the fifth grade of elementary school as an example, two parallel classes in Primary School J were selected as the experimental group(21 students) and the control group(20 students), through the pre-and post-tests of scientific literacy, the students' journals, and other process dates, as well as student interviews, to assess the effectiveness of the practice, based on which the project-based teaching strategies and suggestions for elementary science under the perspective of productive failure are summarized. Currently, the relevant data of the study is being collected and organized.

## Abstracts of Parallel Session 2

### 1.2 Eye-Tracking Research in Science Education [B4-LP-09]

3 January 2025 | 15:45-16:45

#### **Utilizing Machine Learning for Intelligent of Scientific Creativity: Leveraging Scientific Knowledge Structure and Eye-Tracking Cognitive-Behavioral Data (paper ID: 134)**

Yangping Li (School of Foreign Studies, Xi'an Jiaotong University), Yang Zhang (Key Laboratory of Modern Teaching Technology, Ministry of Education), Ruizhen Xi (School of Psychology, Shaanxi Normal University), Tingting Xuan (School of Psychology, Shaanxi Normal University) and Weiping Hu (Key Laboratory of Modern Teaching Technology, Ministry of Education)

**Keywords:** Undergraduate, Empirical research, Scientific creativity, Semantic network, Machine learning

**Abstract:** Scientific creativity is essential in science education, as it promotes advanced cognitive abilities and inspires students to solve scientific problems inventively. Accurate assessment and measurement of scientific creativity is the fundamental prerequisite and guarantee for its efficient cultivation. We developed a machine learning model to intelligently assess scientific creativity based on the structure of scientific knowledge represented by semantic network parameters and attention patterns in cognitive behaviors represented by blink duration. The model achieved a predictive accuracy of over 90%. The predictive performance of the model is predominantly determined by the semantic network parameter CC and the eye-tracking parameter blink duration among the six input layer's feature vectors, with their importance exceeding 30% each and their collective total contribution reaching up to 77%. This study pioneers the application of machine learning to assess scientific creativity via knowledge structure and cognitive data. It transforms traditional assessments, eliminates subjectivity, provides rapid feedback, and streamlines the process via an automated, unbiased method, thereby improving reliability, reducing evaluator workload, and promoting modernized and efficient evaluation practices in science education. To summarize, the findings of this study have a significant role in promoting the identification, evaluation, and cultivation of reserve talents for scientific innovation.

#### **From Novice to Expert: Cognitive Mechanism of Scientific learning: Evidence from Negative Priming Paradigms and Eye Movements (paper ID: 78)**

Shaona Zhou (South China Normal University) and Yushan Xiong (South China Normal University)

**Keywords:** Inhibitory Control, scientific concepts in middle school, cognitive development, eye-tracking analysis, empirical research

**Abstract:** Recent research in educational neuroscience indicate that preconceptions persist alongside newly acquired scientific knowledge, potentially reactivating to influence reasoning and problem-solving. In this process, the inhibitory control mechanism plays an important role. In order to understand the inhibitory control process of novice students in overcoming misconceptions during scientific learning, this study explores the inhibitory control process of novice students in overcoming misconceptions related to physical buoyancy through a negative priming paradigm experiment incorporating eye-tracking technology. The results show that inhibitory control plays a critical role in novice students' overcoming the misconception that the greater the depth, the greater the buoyancy. Repeated measures ANOVA reveals that students at different levels and experimental conditions significantly affect response time, with expert students demonstrating significantly shorter response times and smaller negative priming effects, indicating higher efficiency in inhibitory control. After intervention, novice students' response times gradually approached those of experts, and the amount of negative priming decreased, reflecting improved efficiency in inhibitory control. Eye-movement data analysis further reveals the cognitive processes and behavioral patterns of novices in different intervention stages. Novices frequently reviewed and compared information from various areas of interest, whereas experts demonstrated more efficient information processing, swiftly identifying and inhibiting the misconception.

#### **The effect of competitive environment on students' physics problem-solving: An eye-tracking study (paper ID: 90)**

Qiuye Li (South China Normal University), Yi Zhong (South China Normal University), Sihang Liang (South China Normal University), Yongxuan Li (South China Normal University), Yifeng Ou (South China Normal University), Shaona Zhou (South China Normal University) and Xianqiu Wu (South China Normal University)

**Keywords:** Competitive learning, Problem-solving, Eye-tracking, (Subject level: University) , (Research type: empirical research)

**Abstract:** As competition is widespread in educational settings and its effects on science learning seem to be complex, how students solve problems in competitive environments has attracted a wide range of attention. The purpose of this study is to explore students' learning performances and the problem-solving processes in the noncompetitive environment and the competitive environment. Four physics multiple-choice problems were selected from Force Concept Inventory (FCI). There were 66 undergraduate students randomly assigned to two conditions (a noncompetitive group and a competitive group) to complete physics multiple-choice questions. The results suggested that there were differences in undergraduate students' learning performances and eye movement behaviours when they completed physics problems under noncompetitive and competitive conditions. The noncompetitive group outperformed the competitive group in solving physics problems, but the competitive group spent less fixation time solving physics problems than the noncompetitive group. Moreover, the noncompetitive group displayed a larger number of revisits to the entire problem than the competitive group. In summary, the competitive environment might impact students' learning. On the one hand, although students in a competitive environment completed physics problems more quickly, the accuracy is low, which can be described as "haste makes waste". On the other hand, as indicated by eye-tracking behaviours, students might employ different problem-solving strategies depending on whether they are in a competitive environment.

## Abstracts of Parallel Session 2

### 2.2 Cognitive Development in Science Education [B4-LP-08]

3 January 2025 | 15:45-16:45

#### Exploring Chinese Primary School Science Teachers' Beliefs, and Practice When Implementing Critical Thinking and Creative thinking (paper ID: 51)

Yani Wu (The University of Auckland), Sally Birdsall (The University of Auckland) and Kirsten Locke (The University of Auckland)

**Keywords:** Teacher beliefs and practice, Critical thinking, Creative thinking, Chinese primary school, Qualitative research

**Abstract:** This presentation, part of a larger PhD study, aims to explore Chinese primary school science teachers' beliefs and practices related to their implementation of critical and creative thinking. The cultural factors that could influence these beliefs within the Chinese context are examined. A case study approach was used to explore teachers' beliefs, backgrounds, experience, classroom practice, instructional designs, and professional development from two Science Teaching and Research Groups, one situated in a public school and the other in a private school. Data were collected using interviews, classroom observations, and field notes from weekly Teaching and Research Meetings, and analyzed using Second-generation Cultural-Historical Activity Theory (CHAT). Preliminary findings indicate that more experienced teachers tend to confine their understanding of critical thinking to the development of thinking skills within the context of science education, aligning with reasoning and argumentation as outlined in the Chinese science curriculum standards. In contrast, more novice teachers place greater emphasis on critical thinking dispositions, focusing on students' critical awareness and thinking habits, both in the classroom and in their daily lives. These novice teachers' understandings could be shaped by the dual influences of Confucian culture experienced before adulthood and self-reflective experiences during higher education, where they had greater exposure to Western cultural perspectives, including literary works and Christian values. Most teachers held positive attitudes toward fostering critical and creative thinking, with a stronger sense of self-efficacy in implementing critical thinking than creative thinking. Relevant teaching strategies were largely developed through in-service training, with district teaching and research officers playing a key leadership role in the process. However, rigid evaluation methods, exam-driven competition amongst schools, one-size-fits-all classroom management approaches, and the overburdening of science teachers with multiple tasks have negatively impacted teachers' implementation of these skills.

#### Inhibiting Specific Misconception or General Intuitive Rule? An Experimental Study on Inhibition of Misconceptions through Multiple Representations of Electric Field (paper ID: 91)

Yue Ming (School of Physics, South China Normal University), Leheng Huang (School of Physics, South China Normal University), Dean Li (School of Physics, South China Normal University), Lei Bao (Department of Physics, The Ohio State University), Keke Yu (School of Psychology, South China Normal University) and Yang Xiao (School of Physics, South China Normal University)

**Keywords:** Multiple representation, Misconceptions, Inhibition, Conflict adaptation, Quantitative research, College student

**Abstract:** Multiple-representation contributes to deeper understanding of scientific concepts, while also exposing learners to a greater diversity of misconceptions. For example, electric field is typically illustrated using vector-field (VF) and field-line (FL) representations, both of which can lead to misconceptions including "greater-density indicates stronger-field" (VF) and "longer-lines imply stronger-field" (FL). Since misconceptions may coexist with scientific conceptions during learning, effectively problem-solving often require inhibiting these misconceptions. However, both misconceptions stem from the same general rule "more A, more B". It is then important to understand whether the inhibition is towards the specific misconception or the general rule, which is investigated using a conflict adaptation paradigm with four prime-probe representational pairs (VF-VF, FL-FL, VF-FL, FL-VF). The primes and probes consist of incongruent (inconsistent predictions between mis- and scientific-conception) and congruent (consistent predictions) items. Results show longer reaction times for incongruent primes than congruent ones (congruency effect), indicating the inhibition of specific misconception in both VF and FL representations. Moreover, the congruency effect in the probe was reduced when primes and probes shared the same representation (VF-VF, FL-FL), suggesting that conflict adaptation under the same representation would facilitate the misconception inhibition. Conversely, when the primes and probes differed in their representations (VF-FL or FL-VF) but maintained the same general rule, the congruency effects in the probes were not significantly reduced, indicating that the inhibition was on the misconception rather than the general rule. These findings provide insights to understanding the mechanism of inhibitory control in problem-solving with multiple representations and its educational implications.

#### The effect of competitive environment on students' physics problem-solving: An eye-tracking study (paper ID: 23)

Junmin Wang (Chongqing normal university) and Yajuan Hu (Chongqing normal university)

**Keywords:** animal ethics, conceptions about animal ethics, conceptual metaphor, pupils, qualitative

**Abstract:** Animal ethics refers to the ethical beliefs and moral attitudes held by humans towards the relationship between humans and animals, which directly affect human decision-making and behavior towards animals and the ecological environment. Understanding students' animal ethics can provide theoretical basis for the design of science textbooks and science teaching activities, and informal science education. Based on the Conceptual Metaphor Theory, this study conducted an interview on a total of 20 pupils, who were from Year 2 (N=10) and Year 6 (N=10), an elementary school in Tongliang District, Chongqing. By the means of Nvivo12 software, it was found that the animal ethics of pupils are anthropocentric; The conceptions about animal ethics of Year 6 students are relatively clear, insisting that human rights are superior to animal rights, and tending to evaluate the value and rationality of animal use from the perspective of human interests; Year 2 students have limited understanding of the relationship between humans and animals, meat consumption, and there are double standards or contradictions; On the premise of not hindering human interests, students are more inclined to treat animals kindly and are more likely to empathize with animals that interact more. To develop the animal ethics of primary school students, it is recommended that teachers use metaphors and Socioscientific Issues reasonably to transform pupils' hierarchical concepts of humans and animals. Parents should guide children to pay attention to animal welfare and develop empathy by increasing opportunities for interaction between children and animals.

## Abstracts of Parallel Session 2

### 3.2 STEM Attitude and Career [D2-LP-10]

3 January 2025 | 15:45-16:45

#### Promoting Gifted Students' STEM Career Perceptions and Interest involving Instruction by Educators and STEM Professionals (paper ID: 35)

Tian Luo (Capital Normal University), Winnie Wing-Mui So (The Education University of Hong Kong), Yu Chen (The Education University of Hong Kong), Zeyu Han (The University of Hong Kong) and Yixuan Wang (The Education University of Hong Kong)

**Keywords:** Gifted students, STEM careers, STEM education, primary, mixed-method

**Abstract:** Although numerous studies have explored the critical contributors of career-related STEM education programs on students' interest, little research has examined the effectiveness of "studying with STEM professionals". This mixed-method study aims to examine the effect of two sequential career-related interventions (educator instructed career-related teaching followed by STEM professional teaching) on gifted primary students' STEM self-efficacy (STEMSE), career-related outcome expectations (STEMOE), career interests (STEMCI) and perceptions of STEM careers. 46 STEM-gifted upper-primary students participated in the two-phase 38-hour intervention with repeated-measure assessments before and after each phase. Interviews and qualitative survey data were also collected to analyse students' learning outcomes. The first phase of the intervention consisted of classroom learning, video-watching of STEM professionals, hands-on activities, and on-site visits with a focus on the STEM inquiry process and STEM careers. The second phase was taught by STEM professionals, including eight career-scenario-based workshops instructed by eight STEM experts, and each student voluntarily participated in two of them. Paired-sample t-tests showed that students' STEMCI, STEMOE, and STEMSE had a significant increase after the first phase of the intervention, with STEMOE showing marginal significance. However, after the two phases, no significant overall changes were found in these constructs. Analysis of interviews and students' drawings suggest that students' perceptions of STEM careers had been diversified during the intervention. Plausible explanations of the results and implications for future interventions are discussed.

#### 促進青少年科學職業理想培養的跨學科課程建構研究 (paper ID: 113)

Ning Wang (MOE Key Laboratory of Modern Teaching Technology, Shaanxi Normal University), Aik-Ling Tan (National Institute of Education, Nanyang Technological University) and Weiping Hu (MOE Key Laboratory of Modern Teaching Technology, Shaanxi Normal University)

**Keywords:** 課程發展, 科學職業理想, 職業期望, 混合方法研究, 實證研究, 高中生

**Abstract:** 世界各國普遍面臨科技創新人才短缺的嚴峻挑戰。為了培養青少年的科學職業理想，一些研究採用了基於STEM課程的干預措施，但很少有研究將職業情境融入STEM課程中。因此，本研究透過發展融合職業情境的跨學科課程，以培養青少年的科學職業理想。本研究主要基於泰勒模式和青少年科學職業理想的影響機制進行課程開發，並在中學進行了課程實踐。結果表明，課程提高了中學生的科學職業理想、科學職業認知，消除了對科學相關職業的性別刻板印象，但對相關自我效能感的提升作用不顯著。最後，本研究也分析了課程實施過程中遇到的挑戰和建議。

#### Navigating Career Development Challenges for STEM Students: The need for a new comprehensive theory (paper ID: 145)

Lawrence P. W. Wong (Independent Researcher)

**Keywords:** Secondary and university students, career guidance, career counseling, career theory, school-to-work transition

**Abstract:** Globally, Hong Kong secondary students are frequently being recognized as elite performers in the International Baccalaureate Diploma Program examination. However, as evidenced by the career choices made by the 23 students who had recorded a perfect score in the 2023-24 cohort of the examination, none of them decided to pursue a scientific career such as becoming an artificial intelligence scientist. This situation challenges our current methods in school-based career guidance and counseling practices as elite students often choose careers that they deem prestigious, ignoring career opportunities that are necessary for strategic technological and economic growth at the national level. This suggests that investment in educational success does not necessarily lead to economic and technological growth that are prioritized by the state government. At the personal level, STEM graduates often face unique barriers in career development because of high competition and the rapidly evolving industry landscape. At the school level, students interested in STEM careers lack adequate teacher support for career planning. These problems reflect the current deficiencies in existing career theories as they tend to focus only on examining how individual psychological constructs guide career decision-making processes and lack a comprehensive view. Although some scholars suggest using Amartya Sen's Capability Approach to address career issues, they overlook its critical weaknesses: welfare egalitarianism, under-theorization and subjectivity. Based on the theoretical and empirical issues highlighted in the above, this paper argues for a new, holistic career theory to address these challenges, discussing its theoretical principles and implications.

#### 鄉村小學科普現況及協同機制研究—以肇慶市德慶地區為例 (paper ID: 146)

Qianwen He (Zhaoqing University)

**Keywords:** 小學, 科學普及, 量化研究

**Abstract:** 我國鄉村科學普及仍處於起步階段，鄉村小學科學專任教師仍普遍缺乏，鄉村學生科學素養普遍不高，科學普及機制研究也相對缺乏。本計畫以肇慶市德慶地區為例，透過問卷調查71位在職小學教師對鄉村小學科學普及教育的認識及現況及政府、高校、社會組織在科普教育中的角色與協同作用，以期為科學普及的發展提供邊際貢獻。研究發現，該地區小學科學普及教育存在（1）專業師資力量不足，教學資源匱乏，培訓需求高；（2）科普活動形式單一，實踐少，缺乏高品質的多元供給面；（3）政府、大學、社會組織三者在小學科普教育中分工與角色不明確等議題。

## Abstracts of Parallel Session 2

### 4.2 Cultivation Creativity through Science Education [D2-LP-09]

3 January 2025 | 15:45-16:45

#### 物理師範生創新能力培養路徑與實務探索 (paper ID: 85)

Hongyang Zhang (15802903170) and Changxing Yang (18220832639)

**Keywords:** 創新能力, 專案式學習, 物理師範生, 培育路徑, 大學, 質性研究, 實證研究

**Abstract:** 創新人才是實施人才強國策略的關鍵力量，也是落實創新國家策略的核心需求。人才培育的關鍵在於教師，對師範生的培養直接影響我國基礎科學教育的發展。基於物理學科的具有高挑戰性的專案式學習是實現對師範生創新能力培養的有效路徑，師範生具身經歷專案的提出、論證、規劃、實施、交流評估和展示等階段，創造性解決專案過程中具有高挑戰性、不確定性、複雜性及模糊性的結構不良的真實問題，實現創新、實踐等關鍵能力和物理學科核心素養等多維發展。

#### K-12科學課程中教學策略提升創造力的統合分析 (paper ID: 142)

Yuanjing Lyu (Shaanxi Normal university), Shuoqi Xiang (Anhui Medical University), Zexuan Jiang (Shaanxi Normal university) and Weiping Hu (Shaanxi Normal university)

**Keywords:** K-12, science education, creativity, Teaching strategy, meta-analysis

**Abstract:** 本研究整合了 78 項研究探討在 K-12 體系中的科學課程（涵蓋科學、物理、化學、生物學及地理領域）內，採用不同教學策略對提升創造力的影響。教學策略分為五個類別：跨學科整合策略、專案式學習策略、顯性反思策略、現實問題解決策略及探究活動策略。結果表明，教學策略應用能夠增強創造力，在混合效應模型中，其優勢比為 12.527，95% 置信區間為 [9.486, 16.542]。透過將教學策略分類作為協變量納入元回歸模型，發現跨學科整合策略在提升創造力方面最為突出。此外，研究也強調了學段的重要性，如在小學階段，探究活動策略對於促進創造力的提升尤為有效。

#### 依托國家戰略科技力量培養青少年科技創新後備人才: 武漢光電國家研究中心的案例研究 (paper ID: 70)

海琴 於 (華中科技大學教育科學研究院) and 簡益 李 (華中科技大學教育科學研究院)

**Keywords:** 國家戰略科技力量, 科技創新後備人才, 青少年, 實證研究

**Abstract:** 國家戰略科技力量，對社會擔負一定的科學教育與科普工作職能。超越於一般性的科技場館，它們在引領科技前沿、培養青少年科學抱負、發現專長、提供機會方面有獨特的優勢。但是，如何發揮國家戰略科技力量的科學教育功能尚未被充分重視。本研究立足武漢光電國家研究中心，調查分析其現有的活動設計理念及其育人效果，探討該類型國家戰略科技力量在培養青少年科技創新後備人才上的成功經驗與進一步努力方向，對擴展科學教育途徑提出政策建議。

## Abstracts of Parallel Session 2

5.2 Science Teachers [D1-LP-08]

3 January 2025 | 15:45-16:45

### **Divergent Perspectives: Taiwan's Teacher Educators and Elementary Teachers' Views on Pre-Service Teachers' Bilingual Science Micro-Teaching Performance (paper ID: 6)**

Jing Yi Liu (Doctoral Student, Department of Science Education, National Taipei University of Education.), Jing-Wen Lin (Professor, Department of Science Education, National Taipei University of Education.) and Hong-Wen Cheng (Associate Professor, Department of Science Education, National Taipei University of Education.)

**Keywords:** bilingual science teacher education, bilingual science micro-teaching performance, teacher educators, elementary teacher, mixed methods research

**Abstract:** In an increasingly globalized world, preparing students to be globally competent and adept at cross-cultural communication is essential. This study driven by the urgent need for bilingual science teacher education, focuses on a content-oriented bilingual science pedagogy program offered by a science education department in Taiwan. The research aims to investigate the perspectives of teacher educators and in-service bilingual elementary teachers regarding pre-service teachers' bilingual science micro-teaching performance. This study, involving 35 pre-service teachers divided into eight groups, employed mixed methods research to collect evaluations of their bilingual science micro-teaching performance. The findings reveal significant differences in evaluation criteria. Teacher educators adopted a holistic evaluation approach, emphasizing alignment with Taiwan's 12-Year Basic Education Curriculum Guidelines, the cultivation of scientific literacy, and the role of classroom language in enhancing students' understanding of science. In contrast, bilingual elementary teachers placed more emphasis on consistency with textbook content, the effects of science concept learning, the practical application of English in daily life, and linguistic accuracy. These differences highlight the influence of evaluators' perspectives, training backgrounds, and contextual environments on their assessments. The results of this study provide valuable insights from an interdisciplinary perspective, underscoring the importance of considering diverse viewpoints in the process of developing effective bilingual science teachers. In addition, the findings also provide implications for practitioners, teacher educators and policymakers in the implementation of bilingual science education.

### **Examining Teacher Noticing: Insights into the Interplay with Motivation, Attitudes, Knowledge, and Skills among Pre-service Teachers with differing experience levels (paper ID: 140)**

Jingxian Wang (Southwest University), Dineke Tigelaar (Leiden University), Shirong Nie (Southwest University), Yuheng Yang (Beijing Normal University) and Wilfried Admiraal (Oslo Metropolitan University)

**Keywords:** Teacher noticing, Information technology, Pre-service teacher, Video-based assessment, Mixed methods

**Abstract:** Insights into teacher noticing can inform teacher preparation programs, ensuring pre-service teachers are equipped with the competence to navigate complex classroom situations. This study examined the relationship between pre-service information technology (IT) teachers' motivation, attitudes, knowledge, and skills and their classroom noticing skills. It also compared pre-service teachers at three different stages: those with no pedagogical knowledge and no practicum experience, those with pedagogical knowledge but no practicum experience, and those with both pedagogical knowledge and practicum experience. Based on Blömeke et al.'s (2015) multi-dimensional model of teacher competence, data were collected from 72 pre-service teachers through surveys, attitude questionnaires, knowledge tests, written comments on videoed teaching sessions, and interviews. The findings indicate that the majority of pre-service teachers' perceptions of critical classroom events emphasize the integration of information technology and pedagogy (72.68%), with 62.71% of their interpretations classified at a medium level. Additionally, 42.27% of decision-making processes were based on student characteristics. Regression analysis revealed that motivation from prior teaching and learning experience significantly influenced perception, pedagogical knowledge of student learning significantly influenced interpretation, while gender and location were important factors in decision-making. More video viewing activities should be considered to improve teacher noticing skills for students undertaking lower-level degrees, and using real-world eye-tracking to investigate teacher noticing across groups with differing experience levels can be considered.

(Next→)

## Abstracts of Parallel Session 2

5.2 Science Teachers [D1-LP-08]

3 January 2025 | 15:45-16:45

### The Impact of Using the High School Chemistry Textbooks (2019 Edition) on Teachers and Students: A Structural Equation Modeling Approach (paper ID: 75)

Fangfang Li (18281975536) and Lei Wang (13501222004)

**Keywords:** Quantitative Research, Secondary School, Impact of Textbook Usage, Structural Equation Modeling

**Abstract:** Since the 21st century, various countries around the world have been engaged in curriculum education reforms, successively introducing new curriculum standards and developing new textbooks based on these standards to assist teachers in implementing teaching and to aid students in their learning processes. Following the implementation of various new curriculum standards and the subsequent adoption of new textbooks, the manner in which students and teachers utilize these new textbooks, the effectiveness of their use, and the subsequent impact have piqued the interest of numerous researchers. Since the autumn of 2019, Mainland China has been progressively implementing new textbooks. This study aims to investigate the impact of the new high school chemistry textbooks on both teachers and students, elevate the level of attention given to textbook usage by educators and learners, and to stimulate the growth of the academic field dedicated to the study of textbook utilization.

The research questions encompass: (1) Does students' use of chemistry textbooks influence their academic achievement in chemistry? (2) Does teachers' use of chemistry textbooks affect their teaching capabilities? (3) Does teachers' use of chemistry textbooks impact students' academic achievement in chemistry, and what is the mechanism of influence?

In response to the research questions, a theoretical model of the impact of textbook usage on teachers and students was constructed. Data were collected from 250 students and 34 teachers in Shandong and Beijing using reliable and valid instruments, including Questionnaires on the Use of the 2019 Edition of High School Chemistry Textbooks (teachers and students), A Questionnaire on Teaching Capabilities of Chemistry Teachers, A Questionnaire on General High School Students' Non-Cognitive Performance in the Context of the New Curriculum, and a chemistry achievement test paper. The theoretical model was fitted and refined using AMOS 26.0 to further explore the path relationships and effects among the variables within the model.

The study findings reveal that the use of textbooks by teachers significantly enhances their teaching capabilities, but has only an indirect impact on students' chemistry non-cognitive performance and chemistry grades. The impact on non-cognitive performance is mediated through the teachers' teaching abilities or the students' use of textbooks. For chemistry grades, the impact is mediated through a sequential mediating process involving teachers' teaching abilities and students' chemistry non-cognitive performance, or through the students' use of textbooks and their chemistry non-cognitive performance. The use of textbooks by students has a direct and significant impact on their chemistry non-cognitive performance, and an indirect impact on chemistry grades mediated by non-cognitive performance.

This study underscores the significance of enhancing the performance of both teachers and students in utilizing textbooks, as it plays a positive role in improving teaching capabilities and academic achievements. It provides evidence supporting the full exploitation of textbooks. It is anticipated that textbooks will be fully utilized in future teaching and learning processes, thereby enhancing the teaching capabilities of educators and the academic achievements of students, thus allowing textbooks to realize their functional value to the greatest extent possible.

### Measuring the validity of the pedagogical content knowledge (PCK) framework for inservice chemistry teachers (paper ID: 6)

Feng Deng (South China Normal University), Wanrong Lan (South China Normal University) and Xiaogang Hu (South China Normal University)

**Keywords:** PCK, Chemistry Teachers, Quantitative Research

**Abstract:** For an extended period, harnessing chemistry educators' expertise for effective teaching has garnered notable attention from educators, researchers, and policymakers in the field. As the heart of teacher professional development, pedagogical content knowledge (PCK) represents a unique knowledge system that distinguishes teachers from subject matter experts. However, to date, a defining theoretical model of PCK remains valuable. Different scholars have divergent views on the composition of PCK, mainly regarding the relationship between Subject Matter Knowledge (SMK) and PCK. Existing research can be divided into two perspectives: transformative and integrated. The transformative viewpoint suggests that SMK and PCK are in a parallel relationship, while the integrated viewpoint suggests that SMK and PCK are in a subordinate relationship. To address this gap, this study attempted to validate a data-driven TPACK survey by implementing it on 181 Chinese preservice chemistry teachers enrolled in a normal university from mainland China. In order to differentiate the theoretical model of PCK, this study aims to develop a PCK scale and attempt to verify the components of PCK and the relationships between these components by conducting a PCK survey on 352 in-service high school chemistry teachers in China. The findings establish the structural validity, convergent validity, discriminant validity, and reliability of the PCK framework through the exploratory and confirmatory factor analyses. Furthermore, the research constructs two equivalent models grounded in a mixed transformative and an integrated viewpoint, innovatively advancing a systematic model. Implications for developing inservice chemistry teachers' PCK and future research were also discussed.

## Abstracts of Parallel Session 3

### 1.3 Nature of Science [B4-LP-04]

4 January 2025 | 10:00-11:00

#### **Exploring Chinese Primary School Science Teachers' Beliefs, and Practice When Implementing Critical Thinking and Creative thinking (paper ID: 16)**

Yani Wu (The University of Auckland), Sally Birdsall (The University of Auckland) and Kirsten Locke (The University of Auckland)

**Keywords:** Teacher beliefs and practice, Critical thinking, Creative thinking, Chinese primary school, Qualitative research

**Abstract:** This presentation, part of a larger PhD study, aims to explore Chinese primary school science teachers' beliefs and practices related to their implementation of critical and creative thinking. The cultural factors that could influence these beliefs within the Chinese context are examined. A case study approach was used to explore teachers' beliefs, backgrounds, experience, classroom practice, instructional designs, and professional development from two Science Teaching and Research Groups, one situated in a public school and the other in a private school. Data were collected using interviews, classroom observations, and field notes from weekly Teaching and Research Meetings, and analyzed using Second-generation Cultural-Historical Activity Theory (CHAT). Preliminary findings indicate that more experienced teachers tend to confine their understanding of critical thinking to the development of thinking skills within the context of science education, aligning with reasoning and argumentation as outlined in the Chinese science curriculum standards. In contrast, more novice teachers place greater emphasis on critical thinking dispositions, focusing on students' critical awareness and thinking habits, both in the classroom and in their daily lives. These novice teachers' understandings could be shaped by the dual influences of Confucian culture experienced before adulthood and self-reflective experiences during higher education, where they had greater exposure to Western cultural perspectives, including literary works and Christian values. Most teachers held positive attitudes toward fostering critical and creative thinking, with a stronger sense of self-efficacy in implementing critical thinking than creative thinking. Relevant teaching strategies were largely developed through in-service training, with district teaching and research officers playing a key leadership role in the process. However, rigid evaluation methods, exam-driven competition amongst schools, one-size-fits-all classroom management approaches, and the overburdening of science teachers with multiple tasks have negatively impacted teachers' implementation of these skills.

#### **An Empirical Research on the Interplay among Science Teachers' Epistemological Belief, Professional Identity and Digital Literacy (paper ID: 62)**

Han Chi (Xi'an International Studies University)

**Keywords:** Epistemological Beliefs, Professional Identity, Digital Literacy, Empirical Research, quantitative research, Primary school science teacher

**Abstract:** Fostering scientific literacy is one of the primary goals of science education, and many scientific practices require digital literacy. Therefore, digital literacy is essential for fostering scientific literacy in the digital world. While numbers of studies researched on the teachers' digital literacy and its influencing factors, most have focused on external factors. There is lack of research on whether teachers' digital literacy is influenced by their cognitive beliefs about the subject matter. The study aims to explore the structural relationships among science teachers' epistemological beliefs, professional identity and digital literacy. In this research, 600 science teachers (469 females and 131 Males) were selected as subjects, and the structural relationship among the three variables-epistemological belief, professional identity and digital literacy-were quantitatively analyzed by using structural equation modeling. The findings suggest that (i) epistemological beliefs concerning the dimensions of certainty, source, and justification are positively related to professional identity; (ii) the four dimensions of science teachers' epistemological beliefs significantly predicted teachers' digital literacy and have both direct and indirect impact on it. (iii) Task perception and self-efficacy within science teachers' professional identity positively and significantly predicted their digital literacy. Thus, The relationship between epistemological beliefs, professional identity, and digital literacy is intricately interconnected. Based on these findings, it is recommended that the training of science teachers in both curriculum development and digital technology be enhanced. Additionally, efforts should be made to strengthen science teachers' epistemological beliefs and professional identity, thereby increasing their enthusiasm and confidence in using digital technologies to improve their professional literacy.

#### **Research on the Presentation Characteristics of the Spirit of Collaboration among Scientists in High School Chemistry Textbooks (paper ID: 97)**

Jiangshan Liu (Central China Normal University) and Yang Deng (Central China Normal University)

**Keywords:** The spirit of collaboration among scientists, High school chemistry textbooks, Discourse analysis

**Abstract:** The spirit of collaboration among scientists is an important component of the spirit of scientists and a significant goal in cultivating young students with the potential to become scientists, so it's necessary to focus more on it under less attention of the intersubjective relationship of scientists. Use the elaboration of national policies and literatures related to the spirit of collaboration among scientists to establish the analysis framework and select high school chemistry textbooks of People's Education Press at different periods and different current versions as the research objects to reveal the presentation characteristics of the spirit of collaboration among scientists contained in high school chemistry textbooks with discourse analysis method. Finally, get four findings, including that high school chemistry textbooks of People's Education Press at different periods has shown an upward trend of the attention to the spirit of collaboration among scientists and have added process descriptions to fully embody the spirit of collaboration; then, compared to Shandong Science and Technology Press and Jiangsu Education Press in 2019, People's Education Press in 2019 includes coding of all dimensions and presents a higher balance of the spirit of collaboration among scientists; Shandong Science and Technology Press and Jiangsu Education Press in 2019 focus on the critical thinking possessed by scientists in the process of inheritance. Based on the above, put forward three enlightenments to highlight the spirit of collaboration among scientists in chemistry curriculum and teaching process to realize the high-level understanding of the scientific research work of scientists.

## Abstracts of Parallel Session 3

2.3 Science Textbooks [D2-LP-08]

4 January 2025 | 10:00-11:00

### Using the Lens of Essential Questions–Perspectives to Investigate the Representations of Chemical Thinking in Chinese Secondary Chemistry Textbooks (paper ID: 56)

Ming Chi (Northeast Normal University) and Changlong Zheng (Northeast Normal University)

**Keywords:** chemical thinking, textbook analysis, essential questions-perspectives framework, school chemistry

**Abstract:** Chemical thinking is a recognized core competence developed in chemical education. This study examines the distribution and representation of chemical thinking in five Chinese high school chemistry textbooks aligned with new national standards. We utilized the essential questions-perspectives (EQ-P) framework, encompassing 12 categories structured around chemical identification, explanation, and synthesis, each from four perspectives. Deductive and inductive content analysis was performed on the main text, figures, tables, margin columns, and experiments/activities as analytical units. A total of 239 textbook excerpts reflecting chemical thinking were identified and analyzed. Deductive coding identified the distribution patterns of the 12 categories, while inductive coding elicited the forms of representation. Results showed that the perspective of interaction among submicroscopic components (e.g., molecules, atoms, ions) for explaining and predicting properties and behaviors dominated the textbooks, surpassing other categories. Three forms of representation were identified: “questions present-perspectives present,” “questions present-perspectives absent,” and “questions absent-perspectives present,” with the last form being most prevalent. Our study put insight into the integration of chemical thinking into textbooks that calls for covering a wide range category of chemical thinking and representing them in a “questions present-perspectives present” form.

### An Empirical Research on the Interplay among Science Teachers' Epistemological Belief, Professional Identity and Digital Literacy (paper ID: 101)

Yan Wang (Shenzhen University) and Jari Lavonen (University of Helsinki)

**Keywords:** energy, textbook, primary school, Finland, China

**Abstract:** Science education reforms have gone across the world, it is assumed countries with high academic performance use similar textbooks, the reasons for the achievement differences have been considered as the result of teaching and learning hours and the different quality of teachers. This study aimed to compare the similarities and differences of energy concepts in Chinese and Finnish primary science textbooks. Selected Chinese and Finnish science textbooks from Grades 3 to Grade 6 were examined in terms of their ways of conceptualizing and organizing content for the teaching and learning of energy. The research found that textbooks from both countries present a similar emphasis on energy at the primary level. However, there are more differences between the two countries. The Chinese textbooks organized the energy concept by the field of “different forms of energy”. The leading idea of energy conservation organizes the Finnish textbooks. Inquiry is the most emphasised competency in the Chinese textbooks, compared to the Finnish emphasises explaining phenomena in scientific ways. The Chinese textbooks suggest the goals to cultivate future scientists and contexts in the lab are highlighted. By contrast, the Finnish textbooks present the goal of teaching future citizens an understanding of science. The textbooks in China merely include key concepts, yet the Finnish textbooks are inclined to be an encyclopedia. These suggest the autonomy differences between teachers in the two countries.

### Visual representations of chemical bonding in China's high school chemistry textbooks over the past six decades (paper ID: 109)

Ying Sun (Anhui Normal University) and Huilei Han (Anhui Normal University)

**Keywords:** Visual representations, chemistry textbooks, chemical bonding

**Abstract:** The purpose of this study is to evaluate the visual representations of chemical bonding and analyze their evolution in Chinese high school chemistry textbooks over the past six decades. Based on the analytical framework proposed by Gkitzia et al. and the Graphical Analysis Protocol, the final analytical tool contained 7 criteria, including: (C1) type of representation; (C2) degree of correspondence between representations comprising a multiple representation; (C3) systematicity; (C4) relatedness to text; (C5) existence and properties of a caption; (C6) semantic relations; (C7) contiguity. A total of 74 visual representations of related content were identified. The results showed that the number of visual representations had gradually increased and the types of representations were enriched, and mainly included symbolic and micro representations. The number of multiple representations was small, but the degree of correspondence improved. Most of the systematicity was low. In addition, most visual representations were completely related and linked to the text with an appropriate caption and placed adjacent to related text. The semantic relations of visual representations have been mostly interpretational. Based on the findings of this study, suggestions are provided for the future chemistry textbooks.

## Abstracts of Parallel Session 3

### 3.3 Exploring the Effects of STEM Learning [D2-LP-10]

4 January 2025 | 10:00-11:00

#### **Unleashing the potential of animated video-watching for fostering pupils' STEM career interests: A mixed-method study (paper ID: 12)**

Zeyu Han (The University of Hong Kong), Wing Mui Winnie So (The Education University of Hong Kong), Yu Chen (The Education University of Hong Kong) and Wai Chin Li (The Education University of Hong Kong)

**Keywords:** STEM career interests, educational animated videos, primary school students, mixed-method study

**Abstract:** Triggering students' STEM career interests has been a critical target of STEM education. Traditionally, secondary school is the mainstream focus of attention, while primary school has been neglected. Indeed, students' STEM career trajectories are akin to an ever-narrowing pipeline, with fewer and fewer students showing interest as they grow. Thus, triggering pupils with STEM career interests at an early age is critical in supporting their long-term career trajectories. Considering the role of video-watching in facilitating conceptual change in STEM learning, this study further investigated the influence of watching animated videos titled "STEM Era" on fostering pupils' STEM career interests. A mixed-method design was adopted. Whether a significant change in 166 Hong Kong pupils' STEM career interests happened was examined through pre- and post-surveys. Follow-up interviews were then conducted with 12 participants, further exploring what and how the elements of the videos contributed to the interest change. A significant change was observed from the quantitative survey results. The qualitative interview analysis captured three meaningful elements of the video content (STEM knowledge, STEM experts, and STEM products) and their relatedness to career interest change. Students' ability beliefs, affective values, and family influence were conveyed as relevant to their STEM career interests. Results suggest using animated video-watching as an effective approach to foster pupils' STEM career interests. Further developments and application of visualisation resources are recommended to represent these identified meaningful elements. Avoiding representing an image of "nerds" but showing a more vivid and comprehensive image of STEM experts is also highly recommended.

#### **Research on the influence of social-scientific issues learning (SSI-L) on students' dialectical thinking (paper ID: 86)**

Ronghua Zhang (Shanxi Teachers University) and Qingqing Ji (Northwest Normal University)

**Keywords:** Secondary School, Study on hybrid methods, social-scientific issues learning, Dialectical thinking

**Abstract:** Social-scientific issues learning is based on the real situation of SSI, the teacher guides the students to carry out the related science, technology, society, Safety, health and ethics multi-level study and various forms of inquiry activities around the issues, it is helpful to cultivate students' scientific literacy and higher-order thinking. In this study, 30 junior high school students from a public school in Linfen were selected as the experimental group to study SSI-L for one year, while the control group did not learn SSI-L, the students in the control group and the experimental group were tested before and after the development of the dialectical thinking scale for social science issues by using the Likert 5-point scale, and the data were analyzed by using the software SPSS20.0, to explore the relationship between SSI-L and the three elements of dialectical thinking (connection, development and contradiction).

#### **Exploring Classroom Activity Experiences and Their Impact on Students' Academic Achievement in Primary School Technology and Engineering: Insights from Mainland China (paper ID: 105)**

Binbin Cai (College of Life Science, Beijing Normal University, Beijing, People's Republic of China) and Cheng Liu (College of Life Science, Beijing Normal University, Beijing, People's Republic of China)

**Keywords:** Technology and engineering, Academic achievement, Classroom activity, Primary School, Quantitative research

**Abstract:** The Primary School Science Curriculum Standards for Compulsory Education (2017 edition) in mainland China officially introduced Technology and Engineering as an independent content area within the primary school science curriculum for the first time. Although classroom activity experience is a key factor influencing students' academic achievement, limited research has investigated its impact on students' academic achievement in primary school technology and engineering. This study developed assessment and measurement tools for primary school technology and engineering, and survey instruments addressing classroom activity experiences. Data were collected from 27,132 primary school students (girls = 12,562; boys = 14,570) and 147 primary school science teachers. The impact of students' classroom activity practice experiences (SCAPE) and teachers' classroom activity guidance experiences (TCAGE) on students' academic achievement (SAA) in technology and engineering was analyzed using significance test of difference. Additionally, through cross-tabulation frequency analyses, the consistency of perceptions between teachers and students regarding classroom activity experience in this field was examined. The results indicated that (i) in technology and engineering, SAA is significantly correlated with SCAPE and TCAGE; (ii) there is a high degree of consistency between teachers' and students' perceptions of technology and engineering classroom activity experiences. These findings have important implications for enhancing teaching practices in primary school technology and engineering.

## Abstracts of Parallel Session 3

### 4.3 Identity in Project-Based Science Learning [D2-LP-09]

4 January 2025 | 10:00-11:00

#### **Cultivation of Middle School Students' Science Identity through Project-Based Learning of Physics. (paper ID: 52)**

Jiaqi Liu (Beijing Normal University), Yangping Zhou (Beijing Normal University) and Chunmi Li (Beijing Normal University)

**Keywords:** Science identity, Project-based learning, Cultivation strategies, Quasi-experimental research, Mixed-methods research, Physics education, Middle school students

**Abstract:** Fostering students' science identity has become one of the key objectives in the latest wave of global science education reform. However, there has been limited research on strategies for cultivating science identity within instructional settings. In recent years, Project-Based Learning (PBL) has proven to be an effective approach for enhancing students' scientific literacy due to its unique advantages, but little attention has been paid to promoting students' science identity in the context of PBL. In response, this study conducted quasi-experimental research under the "Regional Promotion of PBL Targeting Core Competencies" project at Beijing Normal University, using questionnaires and interviews to assess the effectiveness of PBL in physics classrooms in fostering middle school students' science identity. The findings suggested that PBL immersed students in the role of scientists and effectively simulated the process of scientific practice. Additionally, the study revealed that enhancing students' recognition as scientists was a critical breakthrough for future teaching practices. To support teachers in fostering students' science identity in the classroom setting, this study proposed eight instructional strategies and developed a learning pathway to promote science identity grounded in the characteristics and components of PBL. This study offers valuable insights for science teachers in designing and implementing classroom instruction to effectively nurture science identity among middle school students.

#### **A Study of Project-Based Curriculum to Promote Chemistry Identity among Junior High School Students with Different Family Science Capital (paper ID: 96)**

Lingyun Yuan (Central China Normal University) and Yang Deng (Central China Normal University)

**Keywords:** Project-based curriculum, Chemistry identity, Family science capital, Junior high school student

**Abstract:** Science identity is an important factor in students' engagement and persistence in science and is influenced by students' family science capital. The project-based curriculum is a powerful intervention for students' science identity. This study focuses on the discipline of chemistry and examines the effectiveness of a project-based curriculum on middle school students with different family science capital in developing chemistry identity. Using Archer's science capital framework and PISA 2025 science identity framework as theoretical foundations, we independently developed a questionnaire on family science capital and chemistry identity, and designed a project-based curriculum with the theme of "Promoting New Energy Vehicles". Using family science capital as a basis for grouping, the development of students' chemistry identity was described based on quantitative statistics and discourse analysis by collecting questionnaires on chemistry identity before and after the project-based curriculum, as well as audio and video materials from the classroom. Results showed that (i) students with high levels of family science capital typically had a high chemistry identity; (ii) students with moderate levels of family science capital had the best chemistry identity development from the project-based curriculum; (iii) and students with low levels of family science capital, although the project-based curriculum significantly increased their interest, enthusiasm, and agency in chemistry, there was also a significant lack of professional dimensions of chemistry identity. Consequently, school science education can effectively develop students' chemistry identity by designing a more targeted project-based curriculum concerning the mature theoretical framework.

#### **Exploring the Formation of High School Students' Science Identity: A Qualitative Study (paper ID: 137)**

Sitong Chen (Chongqing Normal University) and Changchun Lin (Chongqing Normal University)

**Keywords:** Qualitative study, High school students, Science identity, Learning and living experiences

**Abstract:** As a sociocultural concept, students' science identity has been widely discussed in the field of science education. Science identity was proved to be a key indicator of students' learning engagement, persistence, and career intentions in science-related fields. Thus, numerous educational efforts have been made to promote students' science identity in former studies. However, most of these studies were focused on students' identity development during undergraduate and postgraduate years, except for few studies exploring students' identity formation during high school which was argued as a crucial period for promoting science identity. This study applied a qualitative method to explore how high school students have come to form their science identities in previous learning and living experiences. Semi-structured interviews were conducted with 8 newly enrolled undergraduate students majoring in science-related fields. As suggested by the narrative data from interviews, students' formation of science identities was driven by five interrelated experiences: growing self-recognition as a science person, achieving success in learning science, getting recognized by influential others, being interested in science subjects, and informal science experiences in various contexts. Specifically, students' success and achievement in science learning could facilitate their interest in science subjects and others' recognition. And their informal experiences could enhance their interest and performance in formal science learning. Furthermore, students' success and interest in science as well as recognition from others together contribute to their self-recognition. Based on results of this study, some practical implications were provided for science teachers and researchers in enhancing high school students' science identities.

## Abstracts of Parallel Session 3

### 5.3 Innovative Science Teaching [D1-LP-08]

4 January 2025 | 10:00-11:00

#### Scientific Teaching Research Based on Kuhn's Paradigm Theory —Taking "phlogiston" as an example (paper ID: 69)

Shang Dou (17809299262)

**Keywords:** Kuhn's paradigm revolution theory, science education, concept of phlogiston, conceptual change, secondary student, theoretical research

**Abstract:** The philosophy of science plays a leading and guiding role in science education; however, research on the application of scientific philosophical theories in the implementation of science teaching remains insufficient. Kuhn's paradigm revolution theory, as a classic theory in the philosophy of science, offers a critical theoretical perspective and direction for the implementation of science education. Beginning with Kuhn's paradigm revolution theory, this article first discusses the foundations and values of integrating this theory into science education, such as both elements exhibit constructive and developmental characteristics, and their integration is beneficial for the advancement and cultivation of students' scientific literacy. Furthermore, the article constructs a science teaching framework based on paradigm theory, highlighting the features of the paradigm theory, which encompass the stages of "pre-science—paradigm—anomalies/crisis—scientific revolution—new paradigm". Finally, the article exemplifies this framework through a teaching design using the concept of "phlogiston" in chemistry. This study provides a new perspective for the implementation of science teaching grounded in the philosophy of science.

#### Exploring Sleep Education for Adolescents through the 7E Model: Insights from a Mixed Methods Study (paper ID: 49)

Zhan Shi (College of Teacher Education, Capital Normal University, Beijing) and Yingzhi Zhang (College of Teacher Education, Capital Normal University, Beijing)

**Keywords:** Health education, Sleep education, Adolescent sleep problems, 7E model, Mixed methods research, High school student

**Abstract:** Although health education is a significant part of school science education, the topic of sleep is rarely addressed. In this study, 7E model was used to develop a course of sleep education. We used mixed methods research to investigate the implementation effect of the course. A total of 34 senior one students from Beijing participated in the course (girls = 24 ; boys = 10 ). Before and after the course, we tested the students' sleep knowledge, attitude and practice(KAP), and found that the average scores of each dimension were improved, among which the scores of sleep knowledge and sleep KAP have been significantly improved. Based on the scores of the questionnaire, we selected three students for interviews. We explored the ways students apply this course to real life. After class, they observed and explained some phenomena in the sleep process of others or animals, changed bad sleep hygiene habits, and shared sleep knowledge with others. By understanding students' sleep-related life background, we found that students' sleep duration was difficult to prolong, it often involves the combined effects of homework, use of electronic equipment, commuting time and school start time. In addition, whether in the family or in school, there is a lack of sleep education for students. The above findings have certain implications for expanding the ways of sleep education for adolescents, and also enhance the confidence of improving adolescents' sleep problems through sleep education.

#### (遊)戲如人生：透過桌遊行為分析永續發展議題表現之關聯研究 (paper ID: 48)

秉漢 鄭 (Department of Science Education, NTUE)

**Keywords:** 桌上遊戲, 情境評量, 遊戲行為, 議題表現, 付出意願

**Abstract:** 永續發展教育相當重要，桌遊做為學習媒材之一，可以模擬情境、促進議題學習；從評量的角度思考，遊戲讓學習者學習和展現知識應用，也具有情境評量的潛力。本研究開發「淨零排放/綠生活」實體桌遊以及遊戲回饋程式，透過程式蒐集個別玩家的遊戲中行為，再以知識測驗、態度量表和個人價值量表，蒐集學習者的議題表現；爾後，分析行為與表現關聯性。結果顯示，(1)在遊戲中的行為，與議題表現正相關的有：個人在能資源耗用的最高最低差異量、調查個人資訊的行動次數、遊戲中關注資訊的次數；(2)與議題表現負相關的遊戲行為：個人在能資源耗用量、調查電廠（公共）資訊的行動次數。透過分析學習者在遊戲的實作狀態，使桌遊可有評估個人議題表現的功用。

## Abstracts of Parallel Session 4

1.4 AI in Science Education [B4-LP-04]

4 January 2025 | 11:15-12:15

### Enhancing Artificial Intelligence Precision and Implement Personalized Teaching in Science Education: Constructing a Science Knowledge Graph (paper ID: 118)

Zijian Yuan (13022898864), Xipei Guo (15332253973) and Weiping Hu (15202933699)

**Keywords:** Science knowledge graph, Artificial intelligence, Personalized teaching platform, Experimental research, Secondary student

**Abstract:** As a research field of Natural Language Processing, the knowledge graph composed of entities and relationships is an effective way to solve the hallucination problem of artificial intelligence and realize personalized teaching. By means of data cleaning and standardization, a corpus of middle school science education consisting of physics, chemistry, biology, geography and computer science was constructed. Then, under the PyTorch framework, ChatGLM-4-9B was used to complete Named Entity Recognition and relationship extraction tasks, and the entity-relationship-entity triplets of knowledge graph construction were obtained and imported into the Neo4j graph database to construct a knowledge graph composed of 9,771 entities and 439 types of relationships. Based on this knowledge graph, a personalized teaching platform for middle school science was constructed by using Django framework. The platform incorporates GPT-3.5 Turbo and the scientific knowledge graph. The findings showed that (i) Students can find learning paths between different knowledge points and build a meaningful knowledge network; (ii) Teachers can quickly retrieval teaching objectives and available learning activities for different grades and subjects; and (iii) The platform includes a science education tutor that uses large language model and graph retrieval augmented generation to help teachers and students in science curriculum. In the specific task of science education, the GPT-3.5 Turbo equipped with knowledge graph has a precision of 0.84, a recall of 0.73, and a F1 score of 0.78, which is more professional than the original GPT-3.5 Turbo. This research provides a way to integrate AI and knowledge graph to carry out personalized science teaching.

### 運用Bloom's Taxonomy理論探討AI人工智慧應用於運動按摩之學習成效 (paper ID: 110)

楊文仲 (高雄師範大學科學教育暨環境教育研究所) and 黃琴扉 (高雄師範大學科學教育暨環境教育研究所)

**Keywords:** 運動按摩課程, Bloom's Taxonomy理論, AI人工智慧應用

**Abstract:** 本研究旨在探討以Bloom's Taxonomy作為分析架構，整合AI技術的教學策略，介入運動按摩教學後的學習成效。評估學生在運動按摩課程的學習效果及對AI技術的接受程度。研究基於新版布魯姆分類學，問卷涵蓋基本信息、基礎知識評估、技能熟練度、學習動機和興趣、以及對AI介入的接受度。本研究共有52學生參與，平均年齡為20.48歲。初步結果顯示，學生中僅有8%的學生能非常清楚了解運動治療一詞的意涵。51.9%的學生認為在AI技術介入教學後，非常同意AI技術在運動按摩學習中的幫助。本研究為運動按摩教學的科技介入提供實證依據，並為未來的教學模式創新提供參考。

### 建構人工智慧時代下的科學教材體系：挑戰、現況與研發策略 (paper ID: 95)

Junxia Zhang (People's Education Press), Haiying Wang (People's Education Press) and Zhongxue Liu (People's Education Press)

**Keywords:** 中小學定性研, 人工智慧時代, 科學教材研發

**Abstract:** 目前，適用於科學教育的數位教學平台多已應用了人工智慧，智慧學習軟體和小程式在科學課堂上得到應用，生成式人工智慧的應用發展迅速，然而，科學教師的數智技能以及數智化科學教育資源和教材的研發仍落後於人工智慧技術的發展速度。為了改善科學教育落後於人工智慧不斷發展的現狀，因應科學教育生態的升級，在科學教材研發過程中，需要組成協同合作的教材研發團隊，在建構教材內容架構時整合人工智慧素養，設計智慧化科學教學工具包，根據教材使用場景打造智適應教學平台，進而建構整合人工智慧的科學教材體系。

## Abstracts of Parallel Session 4

### 2.4 Science Curriculum Development and Implementation [D2-LP-08]

4 January 2025 | 11:15-12:15

#### **New era primary school science education and its implementation path innovation research report (paper ID: 84)**

Ziquan Zhong (South China Normal University)

**Keywords:** science education, science literacy, primary school science

**Abstract:** In the new era, China is implementing strategies for rejuvenation through science and education, strengthening the country with talent, and promoting innovation-driven development. Innovation has emerged as a key theme, and enhancing the scientific literacy of the entire population is crucial for fostering innovation. Science education focuses on cultivating the scientific literacy essential for modern individuals in the age of science and technology, with a core emphasis on nurturing an innovative spirit. The primary school years represent a golden period for shaping students' qualities and laying the groundwork for advanced scientific knowledge acquisition. Thus, exploring the implementation pathways of science education in primary schools is vital for elevating the scientific literacy of the populace. Taking Guangdong Province as a case study, this research employs online and offline methods, including surveys, interviews, and social practices. Activities like developing community-based public science courses in Guangzhou, visiting large-scale science museums, attending summer schools for science education, and teaching science classes in rural primary schools in Shanwei are undertaken. These efforts aim to proactively explore innovative models for implementing science education in primary schools in the new era. Additionally, the study offers recommendations to the government, society, primary schools, and science educators for innovating implementation paths, contributing wisdom to the construction of a high-quality science education system with Chinese characteristics.

#### **The Current Status and Challenges of Promoting Ocean Literacy Education: A Qualitative Study on Teachers' Experiences (paper ID: 141)**

貴蘭 楊 (886-8-8825080), 振方 洪 (886-7-7172930#7000) and 芃儒 賴 (886-8-8825001#5508)

**Keywords:** Ocean literacy education, Teaching challenges, Technology Integration in Ocean Literacy, K-12 teachers, qualitative research

**Abstract:** Ocean literacy education has emerged as a critical priority in the 21st century, yet the challenges that educators face in its implementation remain insufficiently explored. This qualitative study investigates the experiences of 52 K-12 teachers who participated in the 2024 Summer Ocean Literacy Training Camp. Through semi-structured interviews with 10 selected participants, four main challenges were identified: limited educational resources, constrained instructional time, the perceived low relevance of training content, and difficulties in integrating technology. Additional barriers included insufficient professional development opportunities and inconsistent curriculum frameworks. Teachers highlighted the lack of teaching materials and tools as a significant impediment to effective ocean literacy instruction. Furthermore, time constraints and low student engagement exacerbated these challenges. Although hands-on and outdoor activities were positively received, translating theoretical content into classroom practice proved difficult. Integrating technology was also hindered by limited access to equipment and technical support. Despite these obstacles, participants noted that peer collaboration during workshops fostered creativity and supported the development of innovative teaching methods. Teachers particularly emphasized the value of hands-on activities and field-based learning in increasing student engagement. Additionally, the integration of ocean literacy into multiple subjects broadened instructional approaches. The findings suggest that ocean literacy training enhances teachers' professional competencies and promotes pedagogical innovation. Future programs should prioritize the comprehensive provision of resources, expand opportunities for field-based learning, and strengthen technical support to maximize the impact of ocean literacy education.

#### **偏遠地區進行化學計畫式學習的困境的敘事研究 (paper ID: 125)**

Yanning Huang (Institute of Teacher Education, Capital Normal University) and Zeshuo Du (The Experimental High school attached to Beijing Normal University)

**Keywords:** 項目式學習, 偏遠地區, 困境, 中學, 質性研究

**Abstract:** 本研究透過個案敘事探討偏遠地區進行專案式學習的可能困境, 利用文本分析法、民族誌等方法收集教學資料及各種訪談資料, 利用敘事研究方法對資料進行編碼, 建構了教師、學生、硬件條件和教育環境四個分析維度。研究結果發現: 偏遠地區教師缺乏計畫式學習中的學生知識和教學策略知識, 以及組織策略單一計畫式學習難以推進的重要因素; 偏遠地區學生學習習慣缺乏、認知能力不足, 部分學生社會情感能力薄弱等會影響計畫式學習進行的進度, 但不構成困境; 學校的硬體支援、教師的教育信念是計畫進行的必要條件, 教育環境會對計畫進行產生影響。

## Abstracts of Parallel Session 4

### 3.4 STEM Attitude and Career [D2-LP-10]

4 January 2025 | 11:15-12:15

#### **STEM capital-building in secondary school and students' STEM identity and career aspiration development (paper ID: 10)**

Yu Chen (The Education University of Hong Kong), Wing Mui Winnie So (Department of Science and Environmental Studies, The Education University of Hong Kong, Hong Kong, PRC.) and Jingsheng Jin (Hangzhou Basic Education Research Institute, Zhejiang, PRC)

**Keywords:** STEM capital, identity, career aspirations

**Abstract:** Motivating students' STEM career aspirations has been a critical target of current school education. Previous studies have indicated the significant role of STEM capital in shaping students' identity and career aspirations and suggested using a STEM capital-building approach. However, limited studies have been conducted to investigate teachers' STEM capital-building practices. Hence, this study examined the associations between capital-building teaching with students' STEM identity and career aspirations through a survey with 3861 Chinese middle school students. Results showed that the majority of the students reported that their teachers would adopt capital-building strategies such as personalizing, eliciting, valuing, or linking sometimes or often, whereas 30% reported that their teachers never or rarely did so. A significant difference was found in capital-building practice across grades. Results also indicated that while the students reported positive STEM identities, fewer of them showed strong career aspirations. Boys scored significantly higher in both identity and career aspirations than girls. Moreover, through multiple regression analysis, capital-building practices were found to be significantly predictive of students' STEM identity and career aspirations. This study has implications for supporting the use of capital-building practices to strengthen students' identity and career aspiration development in secondary schools.

#### **The role of pre-questions and feedback in learning engagement in STEM: the moderating effect of prior knowledge (paper ID: 80)**

Qian Huangfu (Southwest University) and Hong Pan (Southwest University)

**Keywords:** Pre-questions, Feedback, Learning engagement, Eye-tracking, EEG, quantitative, College student

**Abstract:** The improved interaction with multimedia content is recognized as an important factor in improving learners' learning outcomes. Therefore, interactive video lectures are increasingly used in digital learning environments to enhance interactivity. Although the literature contains much research on multimedia-based learning engagement and video lectures, there is a scarcity of studies on whether and to what extent pre-questions and feedback in video lectures affect students' learning engagement, especially in the context of STEM. Two experiments were performed in this study. Experiment 1 aimed to test the effects of pre-questions and feedback on student learning from STEM video lectures in terms of their attention allocation, learning engagement, and learning performance. Results of Experiment 1 indicated that the video lectures with pre-questions and without feedback induced more attention allocation to relative and all contents, increased learning engagement, and enhanced learning performance than the other video types. Experiment 2 tested whether the prior knowledge moderated the effects of pre-questions and feedback on students' attention allocation, learning engagement, and learning performance. Results of Experiment 2 showed when they watched the STEM video lecture with pre-questions and without feedback, students with a low level of prior knowledge showed improved cognitive engagement and retention scores, whereas students with a high level of prior knowledge didn't show the same effect. The results have implications for video designing: if students have a low level of prior knowledge, the STEM video lecture is encouraged to show pre-questions and not show feedback.

#### **透過「科學探究競賽—這樣教我就懂競賽」資料分析 探討學習者參與科普競賽之動機 (paper ID: 45)**

琴扉 黃 (國立高雄師範大學科學教育暨環境教育研究所), 振宇 蔣 (財團法人國家實驗研究院高速網路與計算中心) and 綠子 陳 (National Kaohsiung Normal University)

**Keywords:** 小學, 中學, 技職高中, 大學, 社會人士, 定量研究方法, 科普競賽融入教育

**Abstract:** 於臺灣舉辦的科學探究競賽, 2024年已邁入第11屆, 自2014以來從參賽者不到500人, 如今已成為代表性的科普競賽之一, 每年涵蓋臺灣新二代、原住民等2000人以上前來報名。為掌握其參賽動機, 本研究透過10年來辦理科普競賽的匿名問卷收集, 分析參與者參加科普競賽的主要動機。結果顯示, 有92.5%參賽者認為, 有助於多元學習且建構解決問題的探究歷程; 91.6%的指導老師認為, 本競賽激發學生對科學探究的積極性, 可作為新課綱教學輔助, 使其在多元形式學習中發揮能力展現; 期許此競賽能提供未來科學教育助力發展。

## Abstracts of Parallel Session 4

### 4.4 Higher-Order Thinking in Science Education [D2-LP-09]

4 January 2025 | 11:15-12:15

#### On the productivity of mechanistic reasoning in elementary science classroom (paper ID: 144)

Xiaowei Tang (University of Macau)

**Keywords:** Mechanistic reasoning, productivity, resources

**Abstract:** A key pursuit of science is to form coherent, mechanistic explanations of natural phenomena. Ideally, engaging elementary students in mechanistic reasoning should contribute to such pursuit in their classroom community. Practically, whether engagements in mechanistic reasoning can be productive is shaped by complex factors. Drawing on a case of fourth graders' inquiry into sound generation and transmission, we identify instances where the students' mechanistic reasoning did and did not contribute to their explanation construction process. Our analysis characterizes various ways mechanistic reasoning can contribute, including conjecturing unobservable agents and processes, motivating extended coherency checking, producing testable predictions in modified contexts, and piecing together a fuller explanation. We also single out prematurely established canonical explanations and the scarcity of unambiguous reasoning resources as two constraining situations. The former allows the unchallenged alternative mechanistic ideas to come back repeatedly in the subsequent explanation construction process. The latter created difficulties in conjecturing coherent accounts and evaluating the coherency of different mechanistic accounts. In the discussion, we draw out research and pedagogical implications regarding the conditions of productive engagements in mechanistic reasoning.

#### Fostering Creativity: A Qualitative Analysis of Latest High School Chemistry Curriculum Standards in East Asia (paper ID: 76)

Fangfang Li (18281975536), Jin Shen (18519025018) and Lei Wang (13501222004)

**Keywords:** Pre-questions, Feedback, Learning engagement, Eye-tracking, EEG, quantitative, College student

**Abstract:** Creativity is crucial in addressing the complex challenges of contemporary society. As educational curriculum reforms continue to deepen globally, an increasing number of countries and regions are making the cultivation of creativity a core objective of educational reform. School curricula are vital in fostering creativity among students. Curriculum standards, as guiding documents for educational courses, are decisive in directing schools and teachers in their efforts to cultivate creativity, emphasizing the importance of creativity cultivation, specific requirements, and guidance suggestions. Chemistry courses, with their unique disciplinary characteristics, are irreplaceable in stimulating and shaping students' creativity.

Considering this, the study selects the current high school chemistry curriculum standards from Mainland China, Hong Kong, Taiwan, Singapore, Japan, and South Korea as research subjects. The goal is to offer new perspectives for understanding the strategies and practices of creativity cultivation within different educational systems. Furthermore, it seeks to provide references and insights into promoting the development of students' creativity. The study primarily focuses on the following three research questions:

- (1) Do the high school chemistry curriculum standards in these four countries and six regions define creativity, and if so, how is it defined?
- (2) What specific requirements do the core elements of the high school chemistry curriculum standards in these four countries and six regions, such as curriculum objective, curriculum structure, curriculum content, curriculum evaluation, and curriculum implementation, propose for fostering creativity?
- (3) How do the high school chemistry curriculum standards in these four countries and six regions guide teachers and schools in their efforts to cultivate students' creativity?

In response to the research questions, this study employs the highly influential 4P creativity framework proposed by Rhodes as the theoretical analytical tool. This framework delineates and defines creativity in terms of person, process, press, and product, providing a clear and explicit deconstruction of the connotations of creativity. It has been widely accepted and recognized in the academic community. Two coders, both doctoral students majoring in chemistry education, independently analyzed and coded the curriculum standards to ensure the reliability of the entire coding process and results. Finally, the intercoder reliability was tested using Cohen's Kappa coefficient, and the results indicated good agreement.

The findings of the study reveal variations in the requirements and guidance for fostering creativity among the high school chemistry curriculum standards in the four countries and six regions. Generally, these regions have aligned with the zeitgeist, acknowledging the importance of nurturing creativity. However, it is regrettable that none of them provides a clear definition of creativity. The curriculum objectives typically call for the development of persons with creativity and specify certain traits. The curriculum content and evaluation sections emphasize the importance of processes and products, while the implementation part focuses more on creating a press to foster the development of creativity. Nevertheless, for schools and teachers dedicated to cultivating students' creativity, the curriculum standards resemble a set of broad guiding principles rather than a detailed manual of operations. Therefore, to break through the current bottlenecks in creativity cultivation, each country and region must provide more actionable guidance and implementation strategies in their respective programmatic documents. This will assist schools and teachers in clearly understanding the goals and methods of creativity cultivation, thus promoting innovative educational practices, and inspiring and developing students' creativity.

## Abstracts of Parallel Session 4

### 4.4 Higher-Order Thinking in Science Education [D2-LP-09]

4 January 2025 | 11:15-12:15

#### 社會科學問題背景下中小學生的科學推論能力發展現況：綜合建構性與批判性觀點. (paper ID: 41)

Xipei Guo (15332253973), Xuemin Hao (18729260710), Xin Ji (13628366180) and Weiping Hu (15202933699)

**Keywords:** 科學推論論證, 社會性科學議題, 小學與中學, 量化研究, 理論建構

**Abstract:** 學生在社會性科學問題背景下的科學推理論證能力 (SSI-SRA) 已經受到了研究者的廣泛關注, 但大多研究僅從建構性的視角出發而相對忽視批判性的SSI-SRA, 且少有研究探討不同個體面臨的SSI-SRA能力發展困境差異性。基於此, 本研究首先綜合辯證法、修辭學、邏輯學三個視角, 將SSI-SRA的能力評量架構重構為四個要素: 建構-主張、建構-理由、批判-主張、批判-理由。隨後, 對248名四年級和230名八年級學生實施了SSI-SRA能力測評, 並對學生的能力發展現狀進行了聚類分析, 發現中小學生的SSI-SRA能力發展特徵可分為五種不同的類型。此外, 多層迴歸分析結果顯示學生的建構性能力對批判性能力沒有顯著的正向影響。

#### Research Progress and Prospect of Scientific Higher-order Thinking (paper ID: 112)

Huanxia Wang (Qufu Normal University)

**Keywords:** Scientific thinking, Scientific higher-order thinking, Scientific investigation, Primary and secondary student, Synthesis study

**Abstract:** The study of scientific higher-order thinking is of great value in promoting the reform of science education, enhancing students' scientific literacy, and cultivating future scientific and technological innovators. Current research in this field involves the investigation of the current development of scientific higher-order thinking and the exploration of its structural qualities and assessment methods, which initially reveals its cultivation path. Analysis of the scope and progress of the existing research reveals that future research in this field can start from exploring the influencing factors on the development of students' scientific higher-order thinking ability, how to effectively incorporate the cultivation of higher-order thinking into science education, how to play the role of teachers in the cultivation of scientific higher-order thinking, and how to utilize artificial intelligence technology to support and enhance the teaching and evaluation of scientific higher-order thinking.

## Abstracts of Parallel Session 4

### 5.4 Development of Assessment Tools [D1-LP-08]

4 January 2025 | 11:15-12:15

#### **Developing and Validating an assessment tool of social responsibility in biology (ATSRB) (paper ID: 24)**

Qian Hui Ge (浙江师范大学教育学院) and Qun Xie (浙江师范大学教育学院)

**Keywords:** Social responsibility, Biology, Quantitative study, Secondary school

**Abstract:** The development of social responsibility is a key goal of biology education in middle school in Mainland China. This study aims to assess high school students' social responsibility (SR) in the biology domain. Based on the literature analysis of SR, the ATSRB was a 28-item questionnaire with three dimensions: perceptions, competence, and emotions. There were 11 items (multiple-choice or open-ended questions) measuring perceptions of responsibility, 7 items (open-ended questions) measuring competence of responsibility, and 10 items (Likert scales) measuring emotions of responsibility. 422 students in grades 10-12 were enrolled in this study. Both classical test theory and item response theory were adopted to analyze the quality of the assessment tool. The findings showed that the ATSRB exhibited good internal consistency reliability. The Likert scale measuring affective dimensions was supported by the confirmatory factor analysis. Pearson's correlation analysis showed that students' performance in Biology was positively correlated with their overall scores on perceptions and competence of responsibility. In addition, the data from the test were fitted to the Rasch partial credit model using the Winsteps program in which the unidimensionality, reliability and person-item distribution map of the test were examined. The analysis showed that all 28 items meet the Rasch model expectation and thus have a potential in assessing high school students' SR in the biology domain. Some suggestions are made which may help students' SR to be better developed in biology education.

#### **Research on the Development and Application of an Evaluation Tool for Junior High School Students' Chemical Science Practical Abilities (paper ID: 131)**

Lu Li (Hebei Normal University) and Chuan Li (Hebei Normal University)

**Keywords:** Measurement and Evaluation, Middle School Students, Science Practice, Chemistry Science

**Abstract:** "Scientific Practice" has replaced "Scientific Inquiry" as the core concept of science education. Scientific Practice encompasses asking questions, planning and executing investigations, utilizing mathematical and computational thinking, developing and using models, analyzing and interpreting data, constructing explanations, engaging in argumentation from evidence, evaluating and communicating information. Based on this framework, an evaluation tool for junior high school students' chemical science practical abilities was developed to describe various levels of their performance. The study employed a questionnaire survey method to collect data from a total of 239 junior high school students in three schools located in the county areas of City T, and utilized the Rasch model for data analysis. The research focuses on four aspects: the quality of the evaluation tool, students' ability levels, current status differences, and so forth. The results indicate that the evaluation tool is reliable in quality, and students' abilities can be categorized into four levels. There is overall room for improvement, with weaker performance observed in model construction and investigation planning. In general, this study developed an evaluation tool using Item Response Theory to assess the current status of junior high school students' chemical science practical abilities, categorize different levels of performance, conduct a difference analysis, and propose corresponding teaching suggestions based on the data analysis results.

#### **Science capital role in elementary school students' aspiration for science career (paper ID: 135)**

Kuay-Keng Yang (National Pingtung University), Ming-Chao Lin (National Pingtung University) and Sheau-Wen Lin (National Pingtung University)

**Keywords:** Science Capital, Students' Science Career aspirations, Connection of Science, Elementary School

**Abstract:** This study examines critical predictors of elementary school students' aspirations for science careers, with a focus on the role of science capital. The science capital assessment tools used in the study were adapted from Jones and Ennes' NextGen Scientist Survey (2021). A total of 608 students from grades 3 to 6 across three districts participated. Exploratory Factor Analysis (EFA) validated the science capital instrument. Pearson correlation analysis revealed that science capital—comprising informal science resources, learning experiences, social capital (such as family mentors in science), and science self-efficacy—significantly predicts students' aspirations toward science careers. The implications of these findings will be discussed. The significance of the study will be discussed.

## Abstracts of Parallel Session 5

1.5 Nature of Science, Socio-Scientific Issue and Inquiry [B4-LP-04]

4 January 2025 | 13:30-14:30

### **Model Content in Elementary and Middle School Science Textbooks: A Comparison with Students' Understanding (paper ID: 149)**

Chin-Cheng Chou (National Taipei University of Education) and Mei-Hung Chiu (National Taiwan Normal University, Graduate Institute of Science Education)

**Keywords:** Ontology, Epistemology, Methodology, Model, Science Textbook

**Abstract:** This study analyzes the frequency and representation of the term "model" in Taiwanese elementary, middle, and high school science textbooks, covering materials from three publishers for grades 3 to 9 in the natural sciences. The results indicate that the term "model" appears infrequently in elementary school textbooks (10 instances), primarily limited to concrete, physical models like the "solar trajectory model," without fully addressing its abstract properties and applications. In contrast, the term appears significantly more often in middle school science textbooks (137 instances), encompassing discussions of ontological, epistemological, and methodological perspectives. A survey of 592 students, including 309 elementary and 283 middle school students, revealed that elementary textbooks focus on concrete physical models, reflected in a lower correct response rate (50%) for ontological questions compared to middle school students (54%). Middle school textbooks emphasize the abstract aspects of models, enhancing students' understanding of ontology. For epistemological questions, elementary students had a correct response rate of 56%, while middle school students scored 64%, indicating that deeper explanations and reasoning about models in textbooks improve students' comprehension. Methodological questions tested students' understanding of model application and revision, with correct response rates of 54% for elementary students and 61% for middle school students, demonstrating that middle school students are more adept at using models in scientific learning. The research results suggest that the way models are presented in textbooks is related to students' understanding of models. It is recommended that future textbooks strengthen the ontological, epistemological, and methodological aspects of models to enhance students' understanding of the nature of scientific models.

### **The Impact of Socio-Scientific Issue Web Searches on Sixth Graders' Scientific Epistemic Beliefs: Exploring the Interaction between Prior Beliefs and Information Positions (paper ID: 102)**

Jing-Wen Lin (National Taipei University of Education)

**Keywords:** information position, scientific epistemic belief, health risk, socio-scientific issue, web search

**Abstract:** This quasi-experimental study examines how learning interventions for web searching on socio-scientific issues (SSIs) with different information positions—positive, negative, and conflicting—affect sixth graders' scientific epistemic beliefs (SEBs). Two health-related SSIs, "students bringing smartphones to school" and "construction of Taiwan's fourth nuclear power plant," were used in a closed-end search environment. Six classes (n = 146) were randomly assigned to different SSI information positions (SSIws-IPs) groups. Participants completed SEB questionnaires before and after the web searches to assess (1) the pre-post learning effects on overall SEBs, two constructs (knowing and knowledge), and four dimensions (source, justification, certainty, and development) within each group, and (2) differences among the groups considering learners' prior SEBs. Results indicated that all three SSIws-IPs interventions positively influenced the knowing construct and the source dimension of SEBs towards a more constructivist view, reflecting developmental progression in students' understanding of knowledge by web searches. However, no enhancement was observed in the knowledge construct and the certainty dimension, indicating limits in students' epistemic development at this learning stage. Johnson-Neyman analyses revealed that students with lower pretest SEBs particularly benefited from positive information positions, showing improvements in the knowing and justification dimensions. In comparison, negative information positions were more beneficial for students with higher pretest SEBs. These findings suggest integrating SSI web search activities with hands-on science inquiry curricula to enhance critical thinking and comprehensive epistemic development. Personalized educational interventions, adapted to students' prior knowledge and beliefs, are recommended for maximum effectiveness in the AI era.

### **Exploring Inquiry-Based Science Teaching in English-Medium Instruction (EMI) Classrooms in China: A Study on Teachers' Understanding, Perceptions, and Practices (paper ID: 9)**

Chaoqun Lu (University of Macau)

**Keywords:** EMI, Inquiry-based science instruction, High school, Translanguaging

**Abstract:** The use of English as a medium of instruction (EMI) for subject teaching in international programmes in China has given rise to research into various aspects of EMI in science classrooms. However, there is a dearth of research on the use of EMI in specific pedagogical strategies for science teaching, such as inquiry-based science teaching. Drawing on data from semi-structured interviews, classroom observations and the collection of class materials, this case study investigates how EMI science teachers understand and perceive conducting inquiry-based science activities in EMI classrooms, and how they cope with the challenges and implement inquiry-based science activities. The findings reveal (1) the tensions that arise between passive English language learning and the mutual learning of scientific inquiry and English, and (2) the contradictory stance between inquiry-based science teaching and EMI policy. Furthermore, the findings demonstrate how these science teachers employed a translanguaging pedagogy – orchestrating multilingual and multimodal resources – to facilitate their students' engagement in scientific inquiry activities and to promote the construction of scientific knowledge. This study holds significant implications for policymakers and science teachers, providing valuable insights into the complexities and practices of inquiry-based science teaching in EMI classrooms.

## Abstracts of Parallel Session 5

2.5 Science Curriculum Implementation[D2-LP-08]

4 January 2025 | 13:30-14:30

### 基於對分課堂教學模式的通識教育核心課程實踐 (paper ID: 26)

Cui Xiaxuan (Fudan University), Ma Shihong (Fudan University) and Zhang Xuexin (Fudan University)

**Keywords:** 對分課堂, 教學模式, 內化吸收, 高等教育, 質性半量化研究

**Abstract:** 「對分課堂」教學模式是基於對分思想，將課堂依序分為講授、內化吸收、討論和師生對話等四個環節，以突顯學生在課程中的主體地位。這個教學模式實行權責對分，教師掌控講授和師生對話這兩個環節，而內化吸收和討論則由學生主導，由此構建真正的教師共同體，讓教育教學獲得最大程度的價值。本文以復旦大學通識教育核心課程《物理與文化》的實踐探索為例，透過收集學生學習資料並彙總分析其效果，顯示此新教學模式相較於傳統教學模式能夠有效提升學生的學習效果，培養學生的多項綜合素質能力，並在一定程度上減輕學生學習壓力。

### 融入科學教育的中學學科「三原色」課程資源發展架構與實施路徑 (paper ID: 68)

仲小敏 (天津师范大学)

**Keywords:** 科學教育, 中學學科, “三原色” 課程資源, 混合方法研究

**Abstract:** 教育、科技、人才是全面建構社會主義現代化國家的基礎性、策略性支撐。在創新人才的時代需求下，融入科學教育成為各學科育人的自覺追求。「三原色」課程資源融合科學探究的藍色理性思維、生命發展的綠色生態、人格發展的紅色溫度融合，是促進科學教育融入教學的重要基礎。本研究在前期研究的基礎上，以課程資源的挖掘作為突破口，探討了「三原色」課程資源賦能科學教育融入中學教學的內在價值以及開發框架的邏輯與要點。結合具體教學案例，歸納了融入科學教育的「三原色」課程資源的實施路徑，拓展了中學各學科的科學育人價值與空間。

### 中學綜合科學課程實施現況調查研究 (paper ID: 55)

Lei Fu (Zhejiang Normal University)

**Keywords:** 綜合科學, 科學課程, 浙江

**Abstract:** 中國浙江省從20世紀80年末開始探索中學綜合科學課程改革，是中國目前唯一實施初中階段綜合科學課程的省份。本研究針對550餘名浙江省初中科學教師進行了問卷調查。研究發現，科學教師接受的綜合科學教育訓練不夠系統完整；在課程實施上，仍有小部分分科教學；教學中大都能採用探究教學；推行綜合科學課程的主要困難是教師的專業知識和專業技能；浙江省推行綜合課程的主要動因是行政推動和教師團隊建設。對於使用較多的浙教版教材，大部分認為教材體現了課程標準理念，有利於發展學生核心素養。

## Abstracts of Parallel Session 5

### 3.5 Exploring the Effects of STEM Learning [D2-LP-10]

4 January 2025 | 13:30-14:30

#### **Effects of Reverse Engineering as a STEM Pedagogy: A Meta-analysis (paper ID: 14)**

Luyao Hou (The education university of HongKong) and Zhihong Wan (The education university of HongKong)

**Keywords:** Reverse engineering, Student learning effects, STEM education, Meta-analysis, Quantitative, Basic and higher education students

**Abstract:** This study aims to determine the effectiveness of reverse engineering(RE) as a STEM Pedagogy through meta-analysis. A total of 14 studies were analyzed by scanning the following databases: Web of Science and EBSCO(Academic Search Ultimate, Academic Search Alumni Edition, MEDLINE, British Education Index, Education Source Ultimate, OpenDissertations, Eric, APA PsycInfo). The overall effect of RE on student learning effects was significant ( $g = 0.373$ ). Furthermore, the tasks mixed with close and open tasks were found to positively moderate the impacts of RE on student learning effects( $g = 1.22$ ) than single close tasks( $g=0.30$ ) and single open tasks( $g= 0.28$ ), RE promoted student learning effects more significantly without teaching assistants( $g=0.52$ ) than with teaching assistants( $g=0.18$ ). Instruction time exceeding 2 hours per week is more appropriate, during which evaluation mode incorporated personal evaluation has more obvious advantages for application. The results of the meta-analysis reinforce the arguments for regarding RE as a powerful learning tool to facilitate student learning development and reveal important factors that should be considered when adopting RE to enhance student learning effects.

#### **A pilot study of primary school students' learning outcomes in STEM education in Shandong Province, China (paper ID: 65)**

Feiyue Wang (Shandong Normal University), Tang Wee Teo (National Institute of Education, Nanyang Technological University, Singapore) and Shoubao Gao (Shandong Normal University)

**Keywords:** Primary students, STEM views, Attitudes, Self-concept, Identity, Experiences, Mixed-method research

**Abstract:** In recent years, integrated Science, Technology, Engineering and Mathematics (STEM) education has been promoted around the world. More and more informal STEM activities are enacted even at the early years such as primary schools. However, integrated STEM curriculum has only began to gain traction in China and especially at the elementary levels. This article reports on a pilot attempt to enact an integrated STEM curriculum for primary school students in schools in Shandong province, China. In particular, we examined the students' views, attitudes, self-concept, identity, and experiences toward STEM education and the curriculum to gain insights into the outcomes of the curriculum. The STEM curriculum was piloted over two hours with 332 Grade 5 and 6 students. Mixed methods including a survey and interviews were used in data collection. Rasch analysis was applied to analyse the quantitative survey data comprising students' responses to the five constructs. The survey findings were complemented with interview data collected with eight students and analysed using emergent coding to provide deeper insights about their views and experiences during the activity. The survey data revealed positive views and experiences on all five constructs and these were substantiated by the interviews. The findings provided insights into pilot STEM curriculum in one China province and open up possibilities for expanding and deepening knowledge about STEM teaching and learning in other provinces in China.

#### **大學生STEM小組互動量表之發展 (paper ID: 151)**

芬美周 (彰化縣立草湖國民中學), 曉林段 (國立彰化師範大學科學教育研究所) and 知勤靳 (國立臺中教育大學科學教育與應用學系)

**Keywords:** 大學生, 定量研究, STEM小組互動, 探索性因素分析(EFA), 驗證性因素分析 (CFA)

**Abstract:** 本研究主要是編製一份大學生STEM小組互動量表, 做為大學教師進行STEM教學時使用。此量表乃參考Herro等人(2017)所發展的「Co-Measure」, 用來評量美國K-12學生在STEAM活動中的協作成效, 篩選適合大學生在STEM活動小組互動狀況之題項以338份有效樣本進行量表之信效度考驗經探索性因素分析(EFA)、驗證性因素分析(CFA)及結構方程模組(SEM)之考驗後, 量表包含「互助合作」與「思考理解」兩個分量表, 在「互助合作」向度信度為.945, 在「思考理解」向度信度為.899, 整體信度為.952, 共計13題題項, 其一階斜交模型之卡方自由度比為4.197 5 RMSEA為0.097 0.1, 整體量表之適切性良好可做為STEM教學時小組互動之參考。

## Abstracts of Parallel Session 5

4.5 Affective Domains of Science Learning [D2-LP-09]

4 January 2025 | 13:30-14:30

### Facial Expression Recognition for Probing Students' Emotional Engagement in Science Learning (paper ID: 3)

Xiaoyu Tang (South China Normal University), Yayun Gong (South China Normal University), Yang Xiao (South China Normal University) and Lei Bao (The Ohio State University)

**Keywords:** Student engagement, Emotional learning engagement, Facial expression recognition, Science teaching, Mixed methods research, Secondary student

**Abstract:** Student engagement in science classroom is an essential element for delivering effective instruction. However, the popular method for measuring students' emotional learning engagement (ELE) relies on self-reporting, which has been criticized for possible bias and lacking fine grained time-resolution needed to track the effects of short-term learning interactions. Recent research suggests that students' facial expressions may serve as an external representation of their emotions in learning. Accordingly, this study proposes a machine-learning method to efficiently measure students' ELE in real classroom. Specifically, a facial expression recognition system based on a multiscale perception network (MP-FERS) was developed by combining the pleasure-displeasure, arousal-nonarousal, and dominance-submissiveness (PAD) emotion models. Data were collected from videos of six physics lessons with 108 students. Meanwhile, students' academic records and self-reported learning engagement were also collected. The results show that students' ELE measured by MP-FERS was a significant predictor of academic achievement and a better indicator of true learning status than self-reported ELE. Furthermore, MP-FERS can provide fine-grained time resolution on tracking the changes in students' ELE in response to different teaching environments such as teacher-centered or student-centered classroom activities. The results of this study demonstrate the validity and utility of MP-FERS in studying students' emotional learning engagement.

### Rural Students' Engagement with Science: An Empirical Analysis with the ASPIRES Framework (paper ID: 21)

Ye Cao (King's College London) and Junqing Zhai (Zhejiang University)

**Keywords:** Science Aspirations, Science Engagement, Science Capital, Urban-rural Divide, COVID-19, Social

**Abstract:** Despite the widespread inequality in science education resources, such as the number and quality of teachers, as well as school facilities between urban and rural areas in China, the issue of urban-rural disparity has often been underexplored in Chinese science education research. This study employed a mixed-methods approach to survey 990 middle school students from urban and rural areas in Jiangsu province, investigating the urban-rural gap in students' science career aspirations and analyzing the key factors influencing rural students' aspirations. The findings reveal that rural students generally have lower science career aspirations compared to their urban counterparts, with school science education being the most significant factor influencing rural students' aspirations. Additionally, science engagement during the COVID-19 pandemic was a strong predictor of rural students' science career aspirations. While there is no significant urban-rural gap in students' participation in extracurricular science activities via the internet, the potential "ocean of misinformation" effect brought about by short videos should not be overlooked. Based on these findings, educational authorities should design science curricula and teaching methods that spark students' interest and enthusiasm for learning, strengthen science career education in rural schools, encourage scientists to engage in widespread science outreach, and foster students' ability to discern misinformation using scientific methods.

### Gender Differences in Middle School Students' Multidimensional Science Learning Self-Efficacy and Its Sources in Mainland China (paper ID: 107)

Binbin Cai (College of Life Science, Beijing Normal University) and Cheng Liu (College of Life Science, Beijing Normal University)

**Keywords:** Science learning self-efficacy, Sources of self-efficacy, Gender, Middle School, Quantitative research

**Abstract:** The main purpose of this study was to investigate the current status and gender differences in middle school students' multidimensional science learning self-efficacy and its sources in Mainland China. A total of 507 middle school students (girls = 233; boys = 274) participated by completing two instruments: the Science Learning Self-Efficacy (SLSE) and the Sources of Science Learning Self-Efficacy (SSLSE) questionnaires. The status of SLSE and SSLSE, along with the relationships between them, was examined using descriptive statistics, correlation analysis, and structural equation modeling. Additionally, significance tests and multi-group structural equation models were employed to assess gender differences. The results indicated that (i) male students scored significantly higher than female students in SLSE and most of its sub-dimensions (except for the "Practical Work" dimension); (ii) male students reported significantly higher levels of Mastery Experience and Social Persuasion compared to their female counterparts; (iii) Mastery Experience and Vicarious Experience were identified as the two most salient influencing sources, with Vicarious Experience having a stronger effect; and (iv) compared to male students, Mastery Experience was found to be more crucial for female students. Furthermore, this study examined the relationships between the sub-dimensions of SLSE and SSLSE, and the existing gender differences in these relationships. These findings have implications for teachers in Mainland China to enhance science learning self-efficacy among students of different genders.

## Abstracts of Parallel Session 5

### 5.5 Innovative Science Teaching [D1-LP-08]

4 January 2025 | 13:30-14:30

#### PISA視角下指向科學素養培育的中學地理教學路徑分析 (paper ID: 64)

利東 劉 (天津師範大學) and 小敏 仲 (天津師範大學)

**Keywords:** PISA 2025, 科學素養, 地理教學, 策略, 中學生, 質性研究

**Abstract:** PISA作為全球性的教育評估工具，其科學素養評估部分強調的是學生解決問題的能力、批判性思考能力以及對科學技術的理解。而地理學科因其綜合性強、涉及面廣的特點，在培養學生科學素養方面具有獨特優勢。然而，目前中學地理教學在科學素養培養上仍有不足。本文旨在探討PISA架構下指向科學素養培育的中學地理教學路徑。文章結合PISA架構對科學素養的要求，基於建構主義學習理論和探究式學習方法，分別從課程內容的調整、教學方式的創新以及評價機制的完善等方面給出具體路徑，為地理教師提供了實用的教學指導，也為進一步提升我國中學生的科學素養水準提供了理論基礎。

#### 基於系統思維培養師範生科學提問能力的策略研究 (paper ID: 43)

Xiaoyang Gong (Tianjin Normal University), Lulu Li (Tianjin Normal University), Yujie Dang (China Science and Technology Museum) and Rui Wei (Beijing Normal University)

**Keywords:** 系統思維, 師範生, 科學提問

**Abstract:** 教師能否提出優質的科學問題是培養學生科學探究能力的關鍵。基於系統思維的金字塔模型，本文以蠟燭燃燒為情境調查了師範生在獨立思考和同儕合作場景中運用三種策略提出科學問題的情況。基於已有框架研究者共同對42名師範生提出的832個科學問題進行編碼，卡方檢定顯示獨立思考場景中，使用單一元素直接設問策略時提出因果前因類問題最多；使用多要素關聯設問策略時提出前因後果類問題最多；使用多事件對比追問策略時提出比較類問題最多。同儕合作場景所得結果基本一致。綜上，基於系統思維的提問策略有助於學生突破思維定勢提出更優質的科學問題。

#### Interdisciplinary Physics Instruction in the Context of Social Media-Driven Socially-Acute Questions: Strategies for Enhancing Conceptual and Reasoning Skills (paper ID: 22)

Zengze Liu (School of Physical Science and technology, Soochow University), Zhifang Sang (School of Physical Science and technology, Soochow University), Yuqing Hou (Shanghong Middle School of Minhang District), Youye Ding (No.2 High School of East China Normal University) and Sudong Pan (School of Physics and Electronic Science, East China Normal University)

**Keywords:** Interdisciplinarity, Hot Internet topics, Physics Instruction, Electric power, quantitative, Secondary student

**Abstract:** Deep conceptual learning is an important part of research in physics education. With the advancement of science and technology, more and more problems are interdisciplinary, and the instruction of physics concepts inevitably takes place in interdisciplinary scenarios. This study organizes interdisciplinary teaching in the form of discussing hot controversial topics on the Internet with the aim of promoting students' understanding of the complexity of hot social issues by stimulating students' motivation and cognitive conflicts, so that they not only transfer their physics knowledge to solve social life problems and enhance deep conceptual learning, but also promote their understanding of the complexity of hot social issues. A controlled study was conducted with Chinese middle school students to assess the efficacy of this novel educational approach. The intervention's impact was measured through pre- and post-tests, which served as indicators of advancements in students' conceptual understanding and reasoning abilities. The findings indicate that the interdisciplinary self-directed learning model, underpinned by SAQ from social media, significantly bolsters students' grasp of core concepts, their capacity for knowledge transfer, and their reasoning competencies. This enhancement is observed in comparison to traditional instructional methods currently employed. The significance of this study is to emphasize the potential of socially-acute questions in social media as a rich context for promoting deep learning in physics education.

## Abstracts of Parallel Session 6

1.6 IT-Enhanced Science Learning [B4-LP-04]

4 January 2025 | 14:30-15:30

### Facial Expression Recognition for Probing Students' Emotional Engagement in Science Learning (paper ID: 83)

Xiaoyu Tang (South China Normal University), Yayun Gong (South China Normal University), Yang Xiao (South China Normal University) and Lei Bao (The Ohio State University)

**Keywords:** Student engagement, Emotional learning engagement, Facial expression recognition, Science teaching, Mixed methods research, Secondary student

**Abstract:** Student engagement in science classroom is an essential element for delivering effective instruction. However, the popular method for measuring students' emotional learning engagement (ELE) relies on self-reporting, which has been criticized for possible bias and lacking fine grained time-resolution needed to track the effects of short-term learning interactions. Recent research suggests that students' facial expressions may serve as an external representation of their emotions in learning. Accordingly, this study proposes a machine-learning method to efficiently measure students' ELE in real classroom. Specifically, a facial expression recognition system based on a multiscale perception network (MP-FERS) was developed by combining the pleasure-displeasure, arousal-nonarousal, and dominance-submissiveness (PAD) emotion models. Data were collected from videos of six physics lessons with 108 students. Meanwhile, students' academic records and self-reported learning engagement were also collected. The results show that students' ELE measured by MP-FERS was a significant predictor of academic achievement and a better indicator of true learning status than self-reported ELE. Furthermore, MP-FERS can provide fine-grained time resolution on tracking the changes in students' ELE in response to different teaching environments such as teacher-centered or student-centered classroom activities. The results of this study demonstrate the validity and utility of MP-FERS in studying students' emotional learning engagement.

### Rural Students' Engagement with Science: An Empirical Analysis with the ASPIRES Framework (paper ID: 87)

Ye Cao (King's College London) and Junqing Zhai (Zhejiang University)

**Keywords:** Science Aspirations, Science Engagement, Science Capital, Urban-rural Divide, COVID-19, Social

**Abstract:** Despite the widespread inequality in science education resources, such as the number and quality of teachers, as well as school facilities between urban and rural areas in China, the issue of urban-rural disparity has often been underexplored in Chinese science education research. This study employed a mixed-methods approach to survey 990 middle school students from urban and rural areas in Jiangsu province, investigating the urban-rural gap in students' science career aspirations and analyzing the key factors influencing rural students' aspirations. The findings reveal that rural students generally have lower science career aspirations compared to their urban counterparts, with school science education being the most significant factor influencing rural students' aspirations. Additionally, science engagement during the COVID-19 pandemic was a strong predictor of rural students' science career aspirations. While there is no significant urban-rural gap in students' participation in extracurricular science activities via the internet, the potential "ocean of misinformation" effect brought about by short videos should not be overlooked. Based on these findings, educational authorities should design science curricula and teaching methods that spark students' interest and enthusiasm for learning, strengthen science career education in rural schools, encourage scientists to engage in widespread science outreach, and foster students' ability to discern misinformation using scientific methods.

### Gender Differences in Middle School Students' Multidimensional Science Learning Self-Efficacy and Its Sources in Mainland China (paper ID: 20)

Binbin Cai (College of Life Science, Beijing Normal University) and Cheng Liu (College of Life Science, Beijing Normal University)

**Keywords:** Science learning self-efficacy, Sources of self-efficacy, Gender, Middle School, Quantitative research

**Abstract:** The main purpose of this study was to investigate the current status and gender differences in middle school students' multidimensional science learning self-efficacy and its sources in Mainland China. A total of 507 middle school students (girls = 233; boys = 274) participated by completing two instruments: the Science Learning Self-Efficacy (SLSE) and the Sources of Science Learning Self-Efficacy (SSLSE) questionnaires. The status of SLSE and SSLSE, along with the relationships between them, was examined using descriptive statistics, correlation analysis, and structural equation modeling. Additionally, significance tests and multi-group structural equation models were employed to assess gender differences. The results indicated that (i) male students scored significantly higher than female students in SLSE and most of its sub-dimensions (except for the "Practical Work" dimension); (ii) male students reported significantly higher levels of Mastery Experience and Social Persuasion compared to their female counterparts; (iii) Mastery Experience and Vicarious Experience were identified as the two most salient influencing sources, with Vicarious Experience having a stronger effect; and (iv) compared to male students, Mastery Experience was found to be more crucial for female students. Furthermore, this study examined the relationships between the sub-dimensions of SLSE and SSLSE, and the existing gender differences in these relationships. These findings have implications for teachers in Mainland China to enhance science learning self-efficacy among students of different genders.

## Abstracts of Parallel Session 6

### 2.6 Developing and Evaluating Science Curriculum [D2-LP-08]

4 January 2025 | 14:30-15:30

#### Ignorance as Drivers of Inquiry: A Theoretical Framework for Evaluating Science Textbooks (paper ID: 117)

Guanzhong Ma (Nanjing University) and Yichen Zhou (Nanjing University)

**Keywords:** Ignorance, Science textbook, Elementary science, Scientific inquiry, Empirical study

**Abstract:** A central goal of science education is to provide students with opportunities to confront and address “unknowns” or gaps in knowledge, akin to the experience of real scientists. This study presents a theoretical framework for examining how “ignorance” is addressed in science textbooks, focusing on three categories: epistemic, methodological, and empirical ignorance. The analysis evaluates the extent to which these textbooks offer students chances to confront and navigate knowledge gaps and uncertainties through open-ended inquiry. Our findings reveal that most textbooks prioritize structured knowledge delivery over fostering encounters with ignorance, limiting students’ exposure to the kinds of uncertainty that drive scientific discovery. These materials often focus on well-established facts and predictable outcomes, leaving little room for students to engage with unresolved questions or ambiguous data. Despite some improvements in integrating inquiry-based tasks that reflect real-world scientific complexities, significant gaps remain. The paper concludes with recommendations for textbook design and instructional strategies that better prepare students to engage with ignorance as an integral part of scientific inquiry.

#### 以證據為基礎的教材微觀分析方法 ——理解教材、用好教材的方法論 (paper ID: 127)

運保 陳 (河南師範大學 物理學院)

**Keywords:** 小學科學、初中科學與物理、高中物理；質性研究、理論研究, 實證研究

**Abstract:** 依據結構-功能理論建構了一套以證據為基礎的教材微觀分析方法。它是基於證據分析一節教材的教學要點、建立知識結構和核心素養目標體系；對教學重難點內容的教學過程加以細緻分析，分析其中各個要素的活動形式、體現的原則、意圖實現的育人價值或教學目標，認識整體教學過程及其特徵。尤其是從任務驅動，方法指導，價值闡述，動機激發等角度幫助教師理解教材的教學設計想法。實踐顯示此方法能幫助科學教師理解教材、用好教材，促進學生深度學習、強化認知過程與後設認知意識，發展學生對核心概念的理解與高階思考能力。

#### 建構小學科學課程中的社會責任內容框架 (paper ID: 39)

Min Li (陝西師範大學教育學部) and Weiping Hu (陝西師範大學現代教育技術教育部重點實驗室)

**Keywords:** 社會責任, 科學的社會責任, 紮根理論, 質性研究, 小學

**Abstract:** 在風險社會背景下，科學課程中的社會責任教育愈加重要。我國新一輪科學課程標準明確了社會責任是科學核心素養的重要組成。然而社會責任內涵模糊且表述零散，為教師教學和學生學習帶來了極大挑戰。本研究基於紮根理論，深入剖析了10個國家和地區的13本現行小學科學課程標準文本。從內涵、主體、物件、內容和素質五個維度，建構了科學課程中社會責任的教學內容體系，從而回答了在科學實踐中何謂負責、誰來負責、對誰負責、負責什麼、以及如何負責這一系列問題。旨在為我國科學課程中的社會責任教學提供有益參考。

## Abstracts of Parallel Session 6

### 3.6 Cross-Disciplinary Learning [D2-LP-10]

4 January 2025 | 14:30-15:30

#### Investigation On the Enhancement of Scientific Creativity in Students through STEAM-Based Courses (paper ID: 11)

Chin-Fei Huang (Graduate Institute of Science Education and Environmental Education, National Kaohsiung Normal University) and Ssu-Wei Chang (Graduate Institute of Science Education and Environmental Education, National Kaohsiung Normal University)

**Keywords:** STEM, problem solving, scientific creativity

**Abstract:** Student engagement in science classroom is an essential element for delivering effective instruction. However, the popular method for measuring students' emotional learning engagement (ELE) relies on self-reporting, which has been criticized for possible bias and lacking fine grained time-resolution needed to track the effects of short-term learning interactions. Recent research suggests that students' facial expressions may serve as an external representation of their emotions in learning. Accordingly, this study proposes a machine-learning method to efficiently measure students' ELE in real classroom. Specifically, a facial expression recognition system based on a multiscale perception network (MP-FERS) was developed by combining the pleasure-displeasure, arousal-nonarousal, and dominance-submissiveness (PAD) emotion models. Data were collected from videos of six physics lessons with 108 students. Meanwhile, students' academic records and self-reported learning engagement were also collected. The results show that students' ELE measured by MP-FERS was a significant predictor of academic achievement and a better indicator of true learning status than self-reported ELE. Furthermore, MP-FERS can provide fine-grained time resolution on tracking the changes in students' ELE in response to different teaching environments such as teacher-centered or student-centered classroom activities. The results of this study demonstrate the validity and utility of MP-FERS in studying students' emotional learning engagement.

#### 基於核心概念的思維型跨學科科學實踐課程設計與實施 (paper ID: 104)

季鑫(陝西師範大學教育學部, 陝西師範大學現代教學技術教育部重點實驗室, 重慶市巴蜀中學校), 郭習佩(陝西師範大學現代教學技術教育部重點實驗室) and 胡衛平(陝西師範大學現代教學技術教育部重點實驗室)

**Keywords:** 思維型跨領域科學實踐, STEAM, 科技創新, 課程設計, 生物多樣性

**Abstract:** 本文在基礎教育階段話語體系中對「跨學科」及「跨學科科學實踐」進行了界定, 基於思維型教學理論, 探討了跨學科科學實踐課程的設計理念、目標、內容及評價策略。以「重慶平行嶺區域遷徙猛禽多樣性調查」計畫為例, 分別從計畫背景、目標及實施過程等方面闡述瞭如何透過因地制宜地融合資源, 建構跨學科學習共同體, 打造智慧學習空間, 開展跨學科學實踐的專案式學習。跨學科科學實踐一種課程建構模式, 也可作為培養創新人才的有效策略, 更是促成師生共同體發展的建構途徑, 最終達成“立德、啟智、強體、育美、促勞”, 全面提升學生跨學科科學核心素養。

#### 基於大觀念的初中科學類學科跨學科主題學習課程建構研究 (paper ID: 15)

春艷 馮 (華南師範大學)

**Keywords:** 大觀念, 跨學科學習, 科學教育, 中學教育, 混合方法研究

**Abstract:** 大觀念作為當下課程與教學改革中的支點, 可以撬動跨學科主題學習課程建構。大觀念可以作為內容組織的邏輯脈絡、大觀念可以作為滲透學科素養的標靶、大觀念可以作為回歸核心概念的錨點。基於大觀念的跨學科主題學習課程建構5S路徑為: 架構課程架構 (Structure) — 搭設雙級主題 (Set up) — 制定課程目標 (Set) — 安排課程內容(schedule) — 設立課程評價 (Set up)。基於大觀念的國中科學類學科跨學科主題學習活動設計架構包含設計挑戰、核心問題、學習目標、學習內容、學習評鑑五個基本要素。

## Abstracts of Parallel Session 6

### 4.6 Higher-Order Thinking in Science Education [D2-LP-09]

4 January 2025 | 14:30-15:30

#### **Role of critical thinking in inductive reasoning under the context of scientific experiment: evidence from the event-related potential (paper ID: 100)**

Haiqiong Zhu (School of Physics, South China Normal University), Tong Li (School of Physics, South China Normal University), Diwei Lian (School of Physics, South China Normal University), Yunjie Ni (School of Physics, South China Normal University), Hanqiu Yu (School of Physics, South China Normal University), Yixi Guo (School of Physics, South China Normal University), Siting Chen (School of Physics, South China Normal University), Lei Bao (Department of Physics, The Ohio State University), Keke Yu (School of Psychology, South China Normal University) and Yang Xiao (School of Physics, South China Normal University)

**Keywords:** Critical thinking, Inductive reasoning, Scientific experiment, Event-related potentials, Science undergraduates, Quantitative research

**Abstract:** Developing students' critical thinking is a crucial goal of science education. Dual-process theory suggests that effective critical thinking requires reasoning based on logical systems rather than prior knowledge or beliefs. However, few studies have explored how critical thinking functions in inductive reasoning mitigate belief biases. This study examines the role of critical thinking in overcoming belief bias during inductive reasoning within a scientific experiment context, specifically a pendulum task. We employed Event-Related Potentials (ERPs) to investigate how science undergraduates applied critical thinking when evaluating the validity of observation-based claims that can be inductively developed based on artificial pendulum experiments (e.g., observations showing that the mass of the bob affects the period, but the string length does not). The task involved claims with conflicting logical validity (logical vs. illogical) and plausibility (plausible vs. implausible), categorizing tasks as incongruent (plausible-illogical; implausible-logical) or congruent (plausible-logical; implausible-illogical). We hypothesized that participants would engage critical thinking to counter the belief bias in incongruent tasks. Results showed that when responding to incongruent tasks, participants exhibited larger N200, N400, and late negative component (LNC) amplitudes, indicating the involvement of cognitive control over a priori knowledge, followed by monitoring the semantic conflict and adjusting to it. In contrast, responses to congruent tasks elicited larger P200 amplitudes, reflecting a greater matching process between inputs and expected information. These findings reveal that scientific critical thinking influences the cognitive neural processes involved in inductive reasoning that addresses belief biases, advancing our understanding of the role of critical thinking in science education.

#### **Does Stress Hinder Creativity? Cognitive Neural Mechanisms and Neuromodulatory Interventions of Stress Affecting Creativity (paper ID: 116)**

Haijun Duan (Key Lab of Modern Teaching Technology, Ministry of Education, Shaanxi Normal University), Yifan Wang (Key Lab of Modern Teaching Technology, Ministry of Education, Shaanxi Normal University), Jiaqi Dang (Key Lab of Modern Teaching Technology, Ministry of Education, Shaanxi Normal University), Wanyi Li (Key Lab of Modern Teaching Technology, Ministry of Education, Shaanxi Normal University) and Wenjuan Fu (Key Lab of Modern Teaching Technology, Ministry of Education, Shaanxi Normal University)

**Keywords:** Stress, Creativity, University students, Multimodal empirical research

**Abstract:** Creativity, a unique human talent, is one of the most important human activities, particularly in education. Nowadays, with the advent of the VUCA era, stress has become an unavoidable part of daily life. Both students and educators often face the need to generate creative solutions under pressure. This study systematically explored the neurophysiological mechanisms of stress affecting creativity and the interventions to enhance creativity by means of neurophysiology and cognitive neuroscience. We found that physiological responses such as cortisol, EBR and pupil diameter under stress can negatively influence creative task performance, in which cognitive flexibility plays an important mediating role. A general decrease in upper-frequency alpha power after stress was also shown, reflecting a bottom-up stimulus-driven processing state. Interestingly, at the group level, stress was shown to improve group creativity performance. At the intervention level, we found that tDCS mitigated creativity impairment by improving stress-induced prefrontal dysfunction. These findings improve our understanding of how stress influences both individual and group creativity, providing a strong theoretical and empirical foundation for fostering creativity in students under pressure. Building on these insights, educators can adopt strategies that more effectively support the creative development of students facing stress. Future research should further investigate the mediating role of the neuroendocrine system and examine individual differences in stress responses to better enhance creative learning environments.

#### **SCPO教學提升高中生化學風險認知的實證研究 (paper ID: 63)**

Liyang Zhu (Zhejiang Normal University) and Chenyang Cui (linping campus, hangzhou high school)

**Keywords:** 中學化學, 化學風險認知, 社會批判與問題導向 (SCPO), 社會性科學議題 (SSI), 實證研究

**Abstract:** 提升學生的科學風險認知程度是風險社會的客觀要求, 也是目前國際科學教育研究的一大熱門。研究採用單組前、後測準實驗法, 以Z省某中學高一學生為對象, 基於SSI教學中的SCPO教學法, 設計並實踐了「食品添加劑的使用」的議題教學, 以提升高中生的化學風險認知程度。結果發現, 此方法能顯著提升高中生的化學風險認知水平, 但各構面的提升效果不同, 「風險後果認知」與「風險責任認知」兩個構面有極顯著提升, 「風險源認知」維度提升效果不顯著, 但整體水準良好。研究為中學化學教師進行風險認知教學提供了啟示。

## Abstracts of Parallel Session 6

### 5.6 Science Teachers' PCK [D1-LP-08]

4 January 2025 | 14:30-15:30

#### 自製創新儀器和做中學為載體的科學教師一體化培養探索 (paper ID: 156)

袁令民 (教研室主任) and 鈺從華 (院長)

**Keywords:** 大中小合作, 自製儀器, 做中學, 教師培養

**Abstract:** 人工智慧的興起對科學教育實踐和科學教育師資培養提出較大挑戰, 學習興趣隨著年級增長而降低, 其在科學領域的職業期望也較為落後。為此, 我們探索以自製創新儀器和做中學為載體的科學教師一體化培養探索。具體包括兩部分研究, 透過一年的教學實驗, 以4C和5F教學法為變量, 樂高積木教具套裝為硬件, 前測、中測和後側顯示, 低年齡段學生在認知 (數學和科學成績、創造力、批判性思考能力) 與非認知向度層面 (課堂自信、小組合作能力、人際溝通能力等) 的有顯著差異。針對高年齡層學生 (中學生) 採取大中院校合作共創創新物理教具, 職前職後一體化, 獲得多項比賽的獎項, 提高了學生職業期待和學習興趣。

#### 共同體 PCK能否促進個體PCK? 以職前物理教師「力與運動」主題下的學生知識為例. (paper ID: 60)

瀾楊 (華南師範大學, 物理學院)、雷包 (俄亥俄州立大學, 物理系) 和洋肖 (華南師範大學, 物理學院)

**Keywords:** 大學, 教師教育, 量化研究, PCK評估, 共識模型

**Abstract:** 學科教學知識 (PCK) 是教師有效教學的核心知識體系, 而PCK共識模式強調特定主題的專業知識作為教師公共知識庫, 有助於教師個別特定主題PCK的發展。本研究以「力與運動」為例, 比較了是否提供迷思概念清單對職前物理教師預測學生學習困難的差異。研究中實驗組被要求根據提供的迷思概念清單預測學生在特定問題的學習困難, 控制組則自由作答。結果表明, 提供迷思概念清單時職前教師對學生學習困難的預測準確性得到顯著提高, 意味著掌握共同體的PCK能有效促進個體的PCK。本研究為PCK共識模式提供了實證證據, 也為職前物理教師的培養提供了啟示。

#### 中學物理教師隱性知識獲取對教研共同體教學創新影響機制與實踐路徑研究 (paper ID: 46)

李富強 (西南大學教師教育學院)、高倩 (西南大學科學教育研究中心)

**Keywords:** 隱性知識獲取, 隱性知識意識, 隱性知識分享, 教研共同體, 教學創新

**Abstract:** 隱性知識是教師專業素養的重要組成部分, 也是教師教學創新的重要來源, 因此如何獲得、辨識、分享、應用隱性知識成為教師專業發展領域的核心研究內容之一。借助已有量表, 以結構方程模型方法, 定量研究我國中學物理教師隱性知識獲取對教研共同體教學創新的影響機制。研究結果顯示: 教師隱性知識獲取透過不同路徑影響教研共同體的教學創新; 教師的做中學在其互動中學與隱性知識意識中起到了中介效應; 教師的教學過程創新在教研共同體隱性知識共享與教學產品創新中扮演中介效應; 知識品質對於隱性知識分享與教學產品創新關係具有正向調節效果。在此基礎上, 提出了教師隱性知識獲取、教導共同體教學創新的提升策略。

## Abstracts of Parallel Session 7

1.7 Science Learning Process [B4-LP-04]

4 January 2025 | 16:00-17:00

### Defining Conceptual Understanding: A Three-Stage Model Using Generative Learning Theory Combined with Dynamic Binding Approach (paper ID: 54)

Shanshan Lu (Shandong Normal University)

**Keywords:** Conceptual understanding, Secondary student, Theoretical research

**Abstract:** Conceptual understanding research is exploring students' understanding and progress of concepts. However, the connotation of understanding is not clear to researchers and teachers. This study provides an explanatory perspective that is based on generative learning theory combined with dynamic generative theory and proposes a three-stage model to define conceptual understanding. The generative learning theory addresses the role of existing knowledge and experience in the process of conceptual understanding, while the dynamic binding solves the problem of how to establish connections between existing knowledge and experience and new knowledge. The three-stage model is the three meanings of conceptual understanding: generating alternative representations, generating conceptual meanings, and generating conceptual frameworks. In the first stage, students' representations de-focus on information, and existing knowledge experiences are activated. In the second stage, students working memory continuously retrieves existing knowledge and experiences from long-term memory, exploring whether a logical connection can be established between this knowledge and new information. The mechanism of this exploration is explained by dynamic binding. The third stage occurs in long-term memory and is sometimes unconscious. It mainly arises in the form of insight, similar to the paradigm shift emphasized in conceptual change. This model can be further integrated with the theory of conceptual change to explore the patterns of students' chemical learning and can be used as an alternative framework to explore the level, development, and difficulties of students' conceptual understanding.

### A Moderated Model of Socio-Economic Status, Peer Relationships, and Science Performance among Primary and Middle School Students (paper ID: 67)

Zhi Liu (Beijing Normal University), Jian Liu (Beijing Normal University) and Tian Xue Cui (University of Macau, Macau)

**Keywords:** Peer closeness, peer conflict, socio-economic status, science performance, quantitative, primary and middle school students

**Abstract:** Peer relationships play a crucial role in shaping students' academic science performance, particularly in the context of socio-economic disparities. However, the moderating effects of peer closeness and peer conflict on the relationship between socio-economic status (SES) and academic science performance remain underexplored. This study proposes a moderation model to examine the moderating effect of peer closeness and conflict on the relationship between SES and science performance among Chinese primary and middle school students. A total of 19,108 4th graders and 9,983 8th graders completed online questionnaires and a standardized science test. The moderation analysis indicated that peer closeness neither predicted students' science performance nor moderated the association between SES and science performance for either grade. In contrast, peer conflict negatively predicted the science performance of 4th graders and moderated the pathway of SES on the science performance of 8th graders. Specifically, with a higher level of peer conflict, the positive relationship between SES and science performance was weaker. The findings elucidate that less conflictual interactions with peers could benefit students' learning performance in science, with the effects of peer conflict differing across various grade levels. These findings highlight the potential benefits of minimizing peer conflict to enhance students' learning outcomes in science, and underscore the importance of addressing peer dynamics in different educational contexts.

### Extending Theory of Planned Behavior Model: the importance of habits and traditional culture in influencing student's physics in-class silence behavior (paper ID: 89)

Yushan Xiong (South China Normal University), Shaorui Xu (Guangdong Mechanical & Electrical Polytechnic), Qiuye Li (South China Normal University), Xiaotong Cui (South China Normal University) and Shaona Zhou (South China Normal University)

**Keywords:** middle school students, in-class silence behavior, traditional culture, habit, theory of planned behavior, quantitative research

**Abstract:** As a non-verbal behavior in the physics classroom, silence behavior has garnered attention from researchers and educators. In science education research, the theory of planned behavior (TPB) has been applied to the study of students' in-class participation, suggesting that attitudes, subjective norms, and perceived behavioral control significantly influence students' intention to participate in class. Additionally, it is suggested that students' in-class silence behavior is influenced by their in-class silence habit and traditional culture. The present study has expanded the TPB to an extended model concerning the factors of in-class silence habit and traditional culture. A sample of 528 senior high school students was enrolled to test the extended model using multiple linear regression analysis and mediation effects. The results indicated that students' attitudes, subjective norms, and perceived behavioral control toward in-class participation exerted a notably positive influence on their in-class participation intention, and students' in-class participation intention had a significant negative effect on in-class silence behavior. Moreover, students' in-class silence habit significantly negatively influenced their intention to participate actively in the physics class, and positively influenced the manifestation of silence within the physics classroom environment. Furthermore, traditional culture exerted a significant positive effect on students' in-class silence behavior. Finally, silence habit, attitude toward in-class participation, subjective norms toward in-class participation, perceived behavioral control toward in-class participation all indirectly affect students' in-class silence through in-class participation intention. The present study examined the applicability of the extended model of TPB in explaining the mechanism of students' silence behavior in the physics classroom.

## Abstracts of Parallel Session 7

1.7 Science Learning Process [B4-LP-04]

4 January 2025 | 16:00-17:00

### Promoting Students' Issues-Based Learning through Navigating Uncertainty (paper ID: 103)

Jing Lin (Beijing Normal University), Chengji Luo (Beijing Normal University) and Hongyan Zhao (Beijing Normal University)

**Keywords:** uncertainty, socio-scientific issues, conceptual uncertainty, epistemic uncertainty, 4M learning cycle, global warming

**Abstract:** Uncertainty is an inherent and compelling feature that drives scientists to explore, question, and discover. Highlighting students' uncertainty and assisting students in navigating it in issues-based science learning is a desirable approach for engaging students in thinking and making sense like scientists and learning to make decisions about socio-scientific issues. However, science teachers often overlook or fail to acknowledge students' uncertainty during science learning, much less use students' uncertainty as an invaluable resource to improve student learning. This study examined the cognitive interactions in a 7th grade classroom to investigate how students perceived, unfolded, maintained, and mitigated their uncertainties when they argued about and modeled scientific data on the phenomenon of global warming. Video recordings and pre- and post-test scores from six lessons were used as data for the study. Employing classroom discourse analysis and comparative analysis of pre-and post-test data, this study collected qualitative and quantitative data to portray the trajectories of students' conceptual and epistemic uncertainties during a 4M learning cycle for navigating uncertainty in exploring global warming, i.e., making sense of uncertainty, making discoveries about uncertainty, making decisions about uncertainty, and making products for uncertainty. The findings of this study may inform the development of science textbooks and teacher instruction, utilizing uncertainty as a pedagogical resource to enhance students' scientific literacy for lifelong sustainability.

## Abstracts of Parallel Session 7

### 2.7 International Perspectives on Science Teaching [D2-LP-08]

4 January 2025 | 16:00-17:00

#### 中國大陸與馬來西亞在職教師教學信念對比研究 (paper ID: 32)

笑鵠 陳 (Sichuan Normal University), 銳 魏 (Beijing Normal University) and 磊 王 (Beijing Normal University)

**Keywords:** DASTT-C, 教學信念, 化學教學

**Abstract:** 「信念」一詞沒有統一的定義。通常而言，信念是指個體所持有的觀點、言語、行動、價值觀等有意識和無意識的心理表徵。教師對於教學決策、教學方法及教學策略都有自己的信念，而這些信念會影響他們在課堂上的教學活動 (Fives & Buehl, 2017)。因此，了解職前及職後教師的教學信念對於教師專業發展及改進教學非常重要 (Guilfoyle等, 2020)。本研究旨在分析中國大陸和馬來西亞華本科化學學生關於課堂組織、教學目標及知識論等教學信念差異。透過調查中國大陸和馬來西亞兩地本科新生對自己高中10年級化學課堂情景的繪畫描述，以比較教師的教學信念。具體來說，本研究旨在回答：關於中國大陸和馬來西亞本科新生對於典型高中化學課堂學習環境的信念，有哪些相似之處和差異？

本研究探討了中國大陸和馬來西亞的本科新生對高中化學教師課堂教學的回顧，改編並使用「科學教師畫像」(DASTT-C) (Thomas, Pedersen & Finson, 2001) 作為定性分析工具分析了123名中國學生與149名馬來西亞學生對化學教與學的回顧觀點。比較分析中國大陸和馬來西亞10年級的化學課堂情境。受到紮根理論的啟發，本研究增加四個開放性問題及一個封閉式問題，透過對學生畫的課堂情景圖及開放性問題的分析，來探查在職教師的教學信念在課堂組織、教學目標及知識論信念等三個方面的表現。研究結果表明，中國和馬來西亞學生大部分回饋出以教師為中心的課堂環境。這兩組學生的進一步比較提供有關實際教學環境的組成。這項研究有助於在職和未來教師更深入地了解教育因素，以促進他們對教學計劃和課堂實踐的自我反思和評估。

#### Research on Teachers' Instructional Support in Kindergarten Science Picture Book Teaching Activities — Based on CLASS Classroom Evaluation System (paper ID: 123)

Nini Zhang (Changchun Normal University) and Zhaowei Liu (Changchun Normal University)

**Keywords:** Science Picture Book Instruction, Instructional Support Behaviors, Classroom Assessment Scoring System for Pre-K

**Abstract:** Using the CLASS-preK framework, this study was conducted across the implementation of thirty science-based picture book lessons for kindergarten students. The results revealed that teachers employed instructional support methods a total of 1,787 times. Among these methods, the quality of feedback approach was utilized most frequently, followed by language modeling and cognitive development. Teachers demonstrated a greater tendency to utilize analytical and reasoning techniques, whereas strategies such as advanced language, integration, and self-talk were less frequently employed. Case-based analyses further indicated that teachers' inadequate and unpolished language failed to adequately guide children's language development, and their limited integration of scientific concepts hindered children's overall construction of scientific knowledge. Additionally, teachers' ineffectiveness in scaffolding behaviors constrained children's exploratory abilities.

In analyzing the reasons for these findings, subjective factors included teachers' lack of a systematic understanding of science picture book instruction, an inadequate comprehension of instructional support, and an unreasonable disregard for children's preexisting skill levels. Conversely, objective factors encompassed those related to the school and parents.

The study concluded with the following recommendations aimed at enhancing the quality of teachers' teaching support strategies in science picture book teaching activities: Firstly, employ linguistic strategies to improve teachers' language demonstration skills. Secondly, prioritize children's development and needs to elevate the quality of teachers' feedback. Lastly, utilize diverse methods to reinforce teachers' knowledge and proficiency in teaching support for science picture books. Ultimately, children's scientific knowledge is optimally transferred when teachers bridge picture books with real-world experiences.

#### Identifying the Blind Spot of Lack of Ecological Perspective and Strategies to Relieve It: An Example of Public Dumping of Milk (paper ID: 73)

Yujing Guo (18909830261)

**Keywords:** public dumping of milk, ecological concepts, eco-humanism

**Abstract:** Public dumping of milk refers to purchasing milk and then pouring it into natural water bodies such as rivers and lakes. Based on the theory of 'Conceptual Guidance and Constraints on Behaviour' from the perspective of Marxist philosophy, we set up questionnaires and interviews (mixed research) for students (secondary school students) based on the above social phenomenon. It is clear that the public's dumping of milk is mainly due to their lack of ecological humanism towards the environment on which they depend for their survival, which is manifested in the misinterpretation of 'life', neglect of 'coordination', 'autopoiesis' and 'wholeness'. Ignoring the 'whole'. In order to solve the series of problems caused by the lack of ecological view, the implementation of concept-based teaching reform and other measures to enhance the scientific literacy of students.

## Abstracts of Parallel Session 7

### 3.7 Assessing Science Learning [D2-LP-10]

4 January 2025 | 16:00-17:00

#### 中國大陸與馬來西亞在職教師教學信念對比研究 (paper ID: 4)

笑鵠 陳 (Sichuan Normal University), 銳 魏 (Beijing Normal University) and 磊 王 (Beijing Normal University)

**Keywords:** DASTT-C, 教學信念, 化學教學

**Abstract:** 「信念」一詞沒有統一的定義。通常而言，信念是指個體所持有的觀點、言語、行動、價值觀等有意識和無意識的心理表徵。教師對於教學決策、教學方法及教學策略都有自己的信念，而這些信念會影響他們在課堂上的教學活動 (Fives & Buehl, 2017)。因此，了解職前及職後教師的教學信念對於教師專業發展及改進教學非常重要 (Guilfoyle等, 2020)。本研究旨在分析中國大陸和馬來西亞華本科化學學生關於課堂組織、教學目標及知識論等教學信念差異。透過調查中國大陸和馬來西亞兩地本科新生對自己高中10年級化學課堂情景的繪畫描述，以比較教師的教學信念。具體來說，本研究旨在回答：關於中國大陸和馬來西亞本科新生對於典型高中化學課堂學習環境的信念，有哪些相似之處和差異？

本研究探討了中國大陸和馬來西亞的本科新生對高中化學教師課堂教學的回顧，改編並使用「科學教師畫像」(DASTT-C) (Thomas, Pedersen & Finson, 2001) 作為定性分析工具分析了123名中國學生與149名馬來西亞學生對化學教與學的回顧觀點。比較分析中國大陸和馬來西亞10年級的化學課堂情境。受到紮根理論的啟發，本研究增加四個開放性問題及一個封閉式問題，透過對學生畫的課堂情景圖及開放性問題的分析，來探查在職教師的教學信念在課堂組織、教學目標及知識論信念等三個方面的表現。研究結果表明，中國和馬來西亞學生大部分回饋出以教師為中心的課堂環境。這兩組學生的進一步比較提供有關實際教學環境的組成。這項研究有助於在職和未來教師更深入地了解教育因素，以促進他們對教學計劃和課堂實踐的自我反思和評估。

#### Design and Implementation of Narrative Assessment in Primary School Science Education under the Framework of Core Competencies (paper ID: 36)

Mingxia Zhang (Qingdao university), Fan Shi (Qingdao university) and Xiaoteng Wang (Qingdao university)

**Keywords:** Elementary Science, Core Competencies, Narrative assessment, Empirical research

**Abstract:** Student academic evaluation is a crucial component and key link in educational assessment, and the narrative evaluation of student achievements aligns with the new requirements of educational evaluation reform in the contemporary era. This evaluation method is an effective approach to assessing students' core competencies and serves as a powerful tool to guide the comprehensive academic development of students. This study, from the perspective of the Structure of the Observed Learning Outcome (SOLO) taxonomy, constructs an evaluation system for narrative assessment of primary school science achievements based on curriculum standards and literature related to academic evaluation. Through narrative assessment, the study diagnoses and provides feedback on students' academic performance, offering personalized guidance suggestions. The research employs a combination of formative and summative evaluation methods, obtaining multi-perspective and multi-dimensional feedback on students' academic achievements through the use of various assessment tools such as student self-assessment scales, peer review scales, and teacher evaluation scales, thereby enhancing the effectiveness of narrative assessment. The subsequent results are currently being verified, and the expected outcomes will provide an empirical foundation for the evaluation of primary school science achievements and offer practical strategies for narrative assessment and application for educators.

#### 中學生化學學習表徵能力的測評研究 (paper ID: 34)

Yanxia Jiang (18668964177) and Haiyan Wang (17873222816)

**Keywords:** 化學表徵能力, 中學生, 化學學習, 評測研究, 混合方法研究

**Abstract:** 化學學習的重要特徵是多重表徵的相互作用。表徵能力是化學學習的核心必要能力，對學生化學學業成就的提升有重要意義。然而很少有研究系統分析中學生化學表徵能力的組成，並深入探討中學生化學表徵能力的水平表現。本研究建構了包括內在表徵能力、外在表徵能力以及科學思維三要素的化學表徵能力構成，建構中學生化學表徵能力水平框架，包括識別、關聯、轉化和整合4個水平，基於水溶液內容主題開發中學生化學表徵能力的評估工具，並對4年級的804名中學生進行測查，研究發現中學生化學表徵能力整體偏低，且表現出顯著的年級差異。9年級學生化學表徵能力平均表現為識別水平，10、11、12年級化學表徵能力平均表現為關聯水平，11年級化學表徵能力均值最高，10年級最低。這項研究對有針對性地進行有效化學教學具有參考價值。

## Abstracts of Parallel Session 7

4.7 STEM Learning [D1-LP-09]

4 January 2025 | 16:00-17:00

### Designing AI enabled STEM Learning Platform for Primary School Students (paper ID: 136)

Jingxi Liu (Department of Mathematics and Information Technology, The Education University of Hong Kong) and Daner Sun (Department of Mathematics and Information Technology, The Education University of Hong Kong)

**Keywords:** Artificial Intelligence, STEM Education, Design Thinking, AI Tutor, Problem-Solving, Mixed methods, Primary School

**Abstract:** This research aims to develop a STEM Intelligent Tutoring System designed to enhance students' problem-solving abilities through personalized learning experiences, incorporating a design thinking approach and an AI tutor. The system leverages artificial intelligence to offer diverse learning resources in the form of text, images, and videos, while catering to various learning preferences and styles. It addresses primary school students' specific challenges in STEM education, focusing on improving their scientific knowledge, methods, and higher-order cognitive skills. A key innovation of this project is the integration of design thinking into the system's development, emphasizing empathizing, define, ideate, prototype and test. The AI tutor adapts learning content dynamically, using a web-based platform to recommend learning materials tailored to students' performance, engagement, and support needs. Students receive personalized problem-solving exercises and detailed feedback on their progress, promoting both engagement and skill development. The research methodology includes pre- and post-test assessments of students' STEM understanding, complemented by surveys and semi-structured interviews to evaluate learning preferences, system usability, and the effectiveness of the AI tutor. The study will involve approximately 50 primary school students, with 10 participating in follow-up interviews for deeper insights. By combining AI-driven personalization with a design thinking framework, this project aims to create an innovative, effective, and engaging STEM learning environment.

### An Analysis of the Tendency and Influence Factors of Preservice Teachers Integrating Artificial Intelligence into STEM Education (paper ID: 154)

Fan Yanhua (Henan University), Sun Fengyao (Henan University) and Sun Nianke (Henan University)

**Keywords:** Artificial Intelligence, pre-service STEM teachers, teacher willingness, quantitative

**Abstract:** In the evolving AI-driven education landscape, it is becoming increasingly important for aspiring STEM educators to integrate AI technologies into their teaching practices. However, research on the willingness of pre-service STEM teachers to incorporate AI into their teaching practices is still lacking. This study examines the factors that influence teachers' willingness to integrate artificial intelligence (WIAI), particularly from the perspective of pre-service STEM teachers' attitudes toward the use of AI in teaching. In this study, a comprehensive survey of more than 200 pre-service STEM teachers was conducted to examine the effects and interrelationships of Technological Pedagogical Content Knowledge (TPACK), Perceived Usefulness (PU), Perceived Ease of Use (PE), and Self-Efficacy (SE) on WIAI. The results elucidate the direct effects of TPACK, PU, PE and SE on WIAI. It was found that TPACK directly affected PE, PU and SE, and PE and PU also directly affected SE. Further analysis shows that PE, PU and SE play a significant mediating role in the relationship between TPACK and WIAI, highlighting the existence of a chain mediation effect. Based on these insights, the study makes a number of recommendations to promote the willingness of pre-service STEM teachers to integrate AI into their teaching practices.

### Teaching design of junior high school physics unit review based on project-based learning -- Take the "Lens and its Application" unit of the Human Education Edition as an example (paper ID: 120)

Yujie Gui (15602483105)

**Keywords:** Project-based teaching, Junior high school, Qualitative research

**Abstract:** Project-based teaching has been gradually popularized in primary and secondary schools in recent years. This paper is a practical exploration of project-based teaching based on the chapter of "Lenses and Their Applications." The project content is to make a homemade camera, which guides students to use the knowledge they have learned to solve specific problems in the project, such as choosing the appropriate lens as the lens, measuring and calculating the range of the camera's tube length, trying and applying methods to enlarge or reduce the image, etc. Further improvements are made based on this, such as what should be done if the lens is dirty and how it will affect the image. Through on-site class observation and questionnaire survey, it was found that (1) students showed more interest in project-based learning in the classroom, (2) students were more actively involved in classroom activities. (3) the students who solved the project problems had greatly increased motivation for learning.

## Abstracts of Parallel Session 7

5.7 Review of Research [D1-LP-08]

4 January 2025 | 16:00-17:00

### ICT-assisted experiments in K-12 science education: a systematic literature review (paper ID: 88)

Leyao Jiang (School of Teacher Education, Nanjing Normal University), Yun Sun (School of Teacher Education, Nanjing Normal University), Shuting Zhu (Xiamen Hubin High School) and Jiawei Song (School of Teacher Education, Nanjing Normal University)

**Keywords:** Science education, ICT-assisted experiments, Systematic literature review, K-12 education

**Abstract:** Many previous studies have confirmed the important role of experiments in science education, which not only in helping students to understand scientific knowledge, but also in developing scientific literacy and practical skills. However, traditional experiments usually suffer from the problems of insufficient experimental equipment, expensive equipment, limited time for experiments, and phenomena that are hard to record in time. To solve these problems, more and more information and communication technologies (ICTs) have been integrated into experiments in science education, such as virtual reality (VR), augmented reality (AR), smartphone and simulation software, but few studies have comprehensively explained the role and significance of ICT-assisted experiments in science education. Therefore, in this study, we will systematically review the relevant studies within the past 15 years from three perspectives: technology, application and impact. Firstly, the technical features of different ICTs and the types of experiments are analyzed. Then, the instruction guidance taken during the experiments and the duration of implementation are determined. Finally, the impacts of the students in terms of their knowledge, attitudes, as well as their competence and literacy are assessed. This study contributes to an in-depth understanding of the characteristics of ICT-supported experiments and the corresponding teaching strategies.

### Mapping research on International Educational Science Research by Chinese mainland scholars: A bibliometric review of the literature in the last 20 years (paper ID: 79)

雪李 (15725226628) and Weiping Hu (15202933699)

**Keywords:** Science education, Bibliometric analysis, Research trend, Review study, Chinese mainland

**Abstract:** The main objective of this study is to use bibliometric methods to explore the international science education research conducted by Chinese scholars since 2000, in order to gain a deeper understanding of the historical trajectory, current status, and future trends of Chinese scholars' international science education research. This study uses the Web of Science database as the source of bibliographic metadata, and then analyzes the data using the Bibliometrix software. From the initial search of 4,677 articles, after strict screening through exclusion criteria, 815 articles were finally selected for in-depth analysis. This study reveals the key themes of Chinese scholars' international science education research from both quantitative and qualitative perspectives, and also conducts in-depth research on core performance indicators related to article output and citation rate. According to the research results, Chinese scholars' international science education research can be roughly divided into three stages: the initial germination period (2001-2012), the slow growth period (2013-2017), and the flourishing period (2018-2024). The main areas of concern include teaching and learning methods in science education, STEM education, information technology-enabled science education, scientific inquiry and research on the nature of science. Among the emerging research topics are artificial intelligence, virtual reality, computational thinking, creativity, and game-based learning. These research results can provide valuable insights and references for Chinese researchers and educators, and help policymakers formulate more scientific education policies to achieve science education reform and promote science education development. Internationally, it can help global scholars initiate and establish international networks and collaborations, and also facilitate scenario-based science education research by international scholars in diverse cultural contexts.

### 基於館校結合的區域性科學教育品質提昇路徑研究 (paper ID: 94)

Huijun Wang (Henan University), Xi Kong (Henan University) and Shuhui Zhu (Faculty of Education, Henan University)

**Keywords:** 館校結合, 科學教育品質, 提昇路徑, 中學科學教學, 理論研究

**Abstract:** 新時代科教興國背景下, 提升基礎教育階段的科學教育品質已成為我國建構教育強國、科技強國、人才強國策略的關鍵一環。科技館、博物館及科學研究院等優質非正式教育資源, 透過提供情境化學習、實務體驗和跨學科學習平台, 對全面促進學生科學素養起著關鍵作用。然而, 目前館校結合仍面臨合作機制尚不完善、課程資源銜接不良、教師實踐能力弱等挑戰, 從而限制了科學教育的實施效果。為此, 研究從教育資源整合、教育模式探索、育人共同體建構三個維度出發, 深入剖析館校結合模式在提昇科學教育品質的核心潛力。同時, 探索基於館校結合的區域性科學教育品質提昇路徑, 透過建構穩定長效的館校合作機制、優化館校課程資源體系、強化教師科學教育能力培訓, 形成具有河南地區特色的實務經驗, 致力於推動河南科學教育品質的高效提升。

## Abstracts of Parallel Session 7

5.7 Review of Research [D1-LP-08]

4 January 2025 | 16:00-17:00

**Lan Wang (College of Physical Science and Technology, Central China Normal University), Shiman Huang (College of Physical Science and Technology, Central China Normal University) and Shouyin Liu (College of Physical Science and Technology, Central China Normal University) (paper ID: 148)**

Lan Wang (College of Physical Science and Technology, Central China Normal University), Shiman Huang (College of Physical Science and Technology, Central China Normal University) and Shouyin Liu (College of Physical Science and Technology, Central China Normal University)

**Keywords:** Compulsory Education, Theoretical Research, Engineering Education, Engineering Literacy

**Abstract:** Globally, there has been an increasing emphasis on engineering education and the cultivation of engineering literacy as key components in nurturing innovative talent. However, within China's compulsory education system, there is currently a lack of engineering courses. The latest Science Curriculum Standards for compulsory Education (2022 Edition) also does not sufficiently highlight engineering education and engineering literacy, and there is a paucity of related research in this area. Against this backdrop, this paper delves into the issues surrounding engineering education and the development of engineering literacy at the compulsory education level, with the aim of clarifying the specific connotations and developmental objectives of engineering literacy during this educational phase. Through a combination of literature analysis and comparative studies, this research first delineates the concept and structural elements of engineering literacy. It then examines the overarching goals for cultivating students' engineering literacy throughout the compulsory education period, along with the phased objectives for different grades. Based on these insights, the study proposes a progressive framework for the development of engineering literacy. This work aims to offer valuable reference points for policymakers and educators who are involved in the future development of related fields.



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