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Bringing Together the T and E of STEAM in Early Childhood Education: Robot Programming as an Approach

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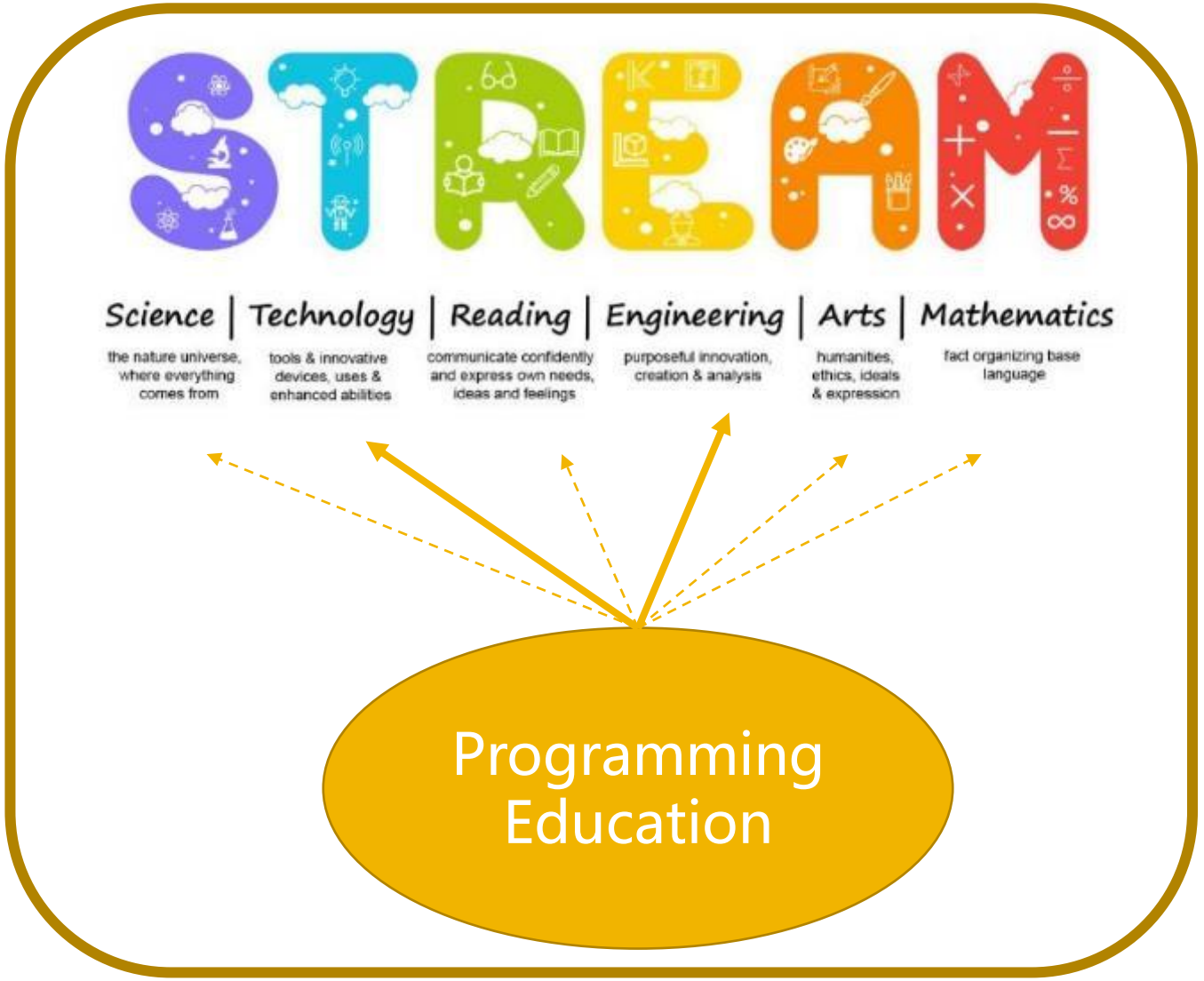
Programming as the Core

- STEM Education
- STEAM Education
- STREAM Education
- Programming Education
- …



Singaporean Children's Learning Story

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There is structural inequality in children's access to age-appropriate and meaningful digital tools and learning opportunities (Su et al., 2022).

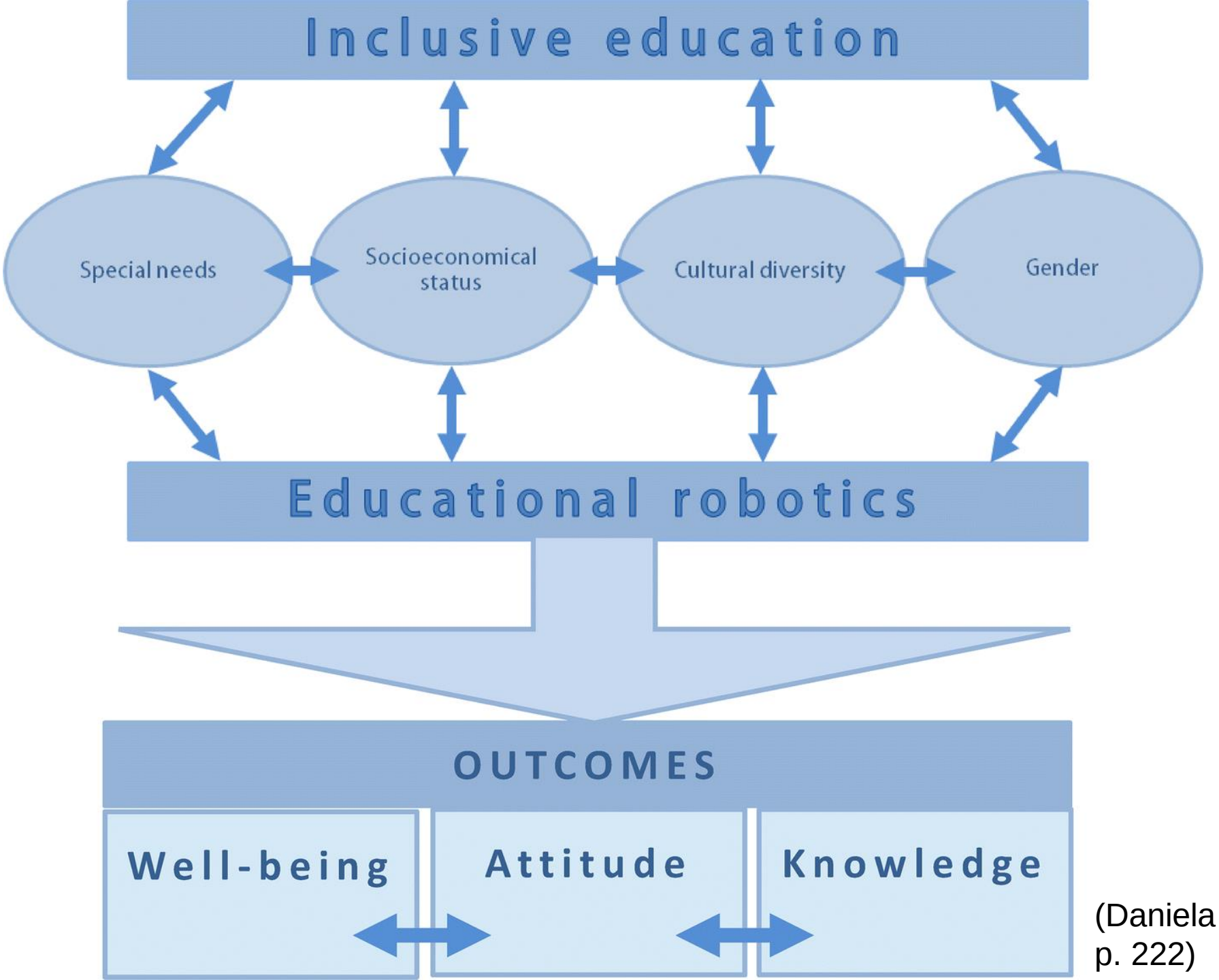
Su, J., Yang, W., & Zhong, Y. (2022). Influences of gender and socioeconomic status on children's use of robotics in early childhood education: A systematic review. *Early Education and Development.* https://doi.org/10.1080/10409289.2022.2078617

- **Boys tend to have a higher level of enjoyment in being an engineer than girls.**
- **Boys generally outperformed girls in robot tasks.**

Su, J., Yang, W., & Zhong, Y. (2022). Influences of gender and socioeconomic status on children's use of robotics in early childhood education: A systematic review. *Early Education and Development.* https://doi.org/10.1080/10409289.2022.2078617

- **Children in high-SES schools have a better understanding of robotics.**
- **Educational robotics tend to be more easily accessible for children whose families can pay for the learning opportunities.**

Su, J., Yang, W., & Zhong, Y. (2022). Influences of gender and socioeconomic status on children's use of robotics in early childhood education: A systematic review. *Early Education and Development.* https://doi.org/10.1080/10409289.2022.2078617



Daniela, L., & Lytras, M. D. (2019). Educational robotics for inclusive education. *Technology, Knowledge and Learning*, *24*(2), 219-225.

(Daniela & Lytras, 2019, p. 222)

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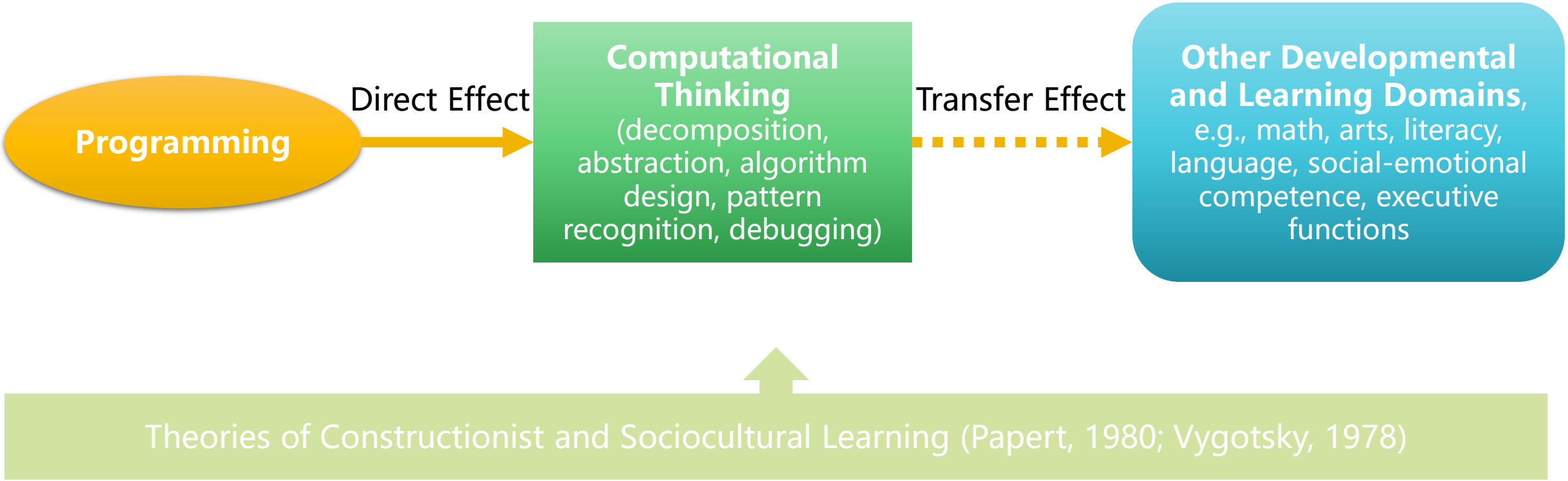
Learning Outcomes



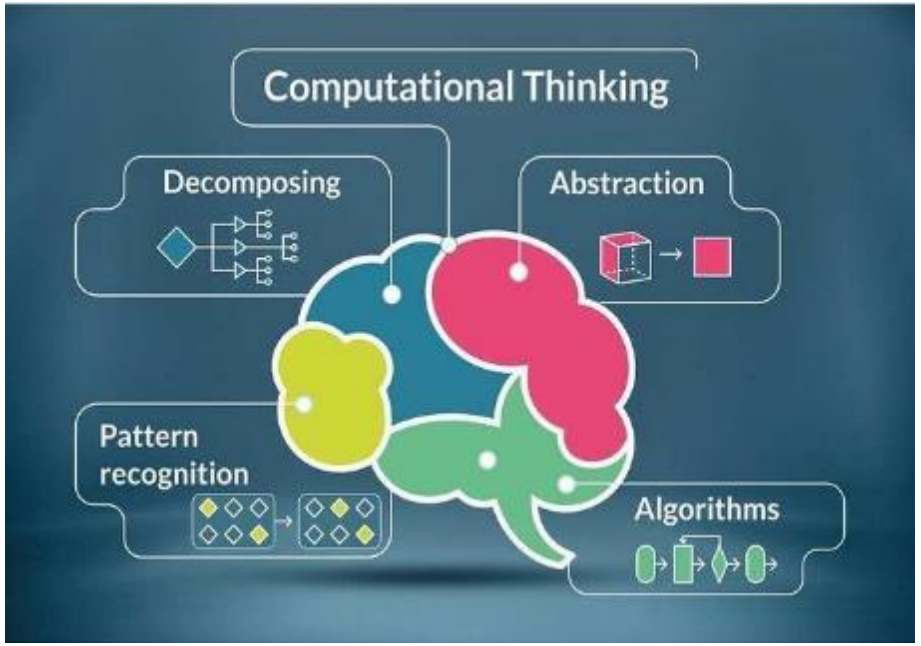
Computational Thinking (CT)

CT involves a range of creative skills such as

(1) designing systems using concepts fundamental to **computer science**,

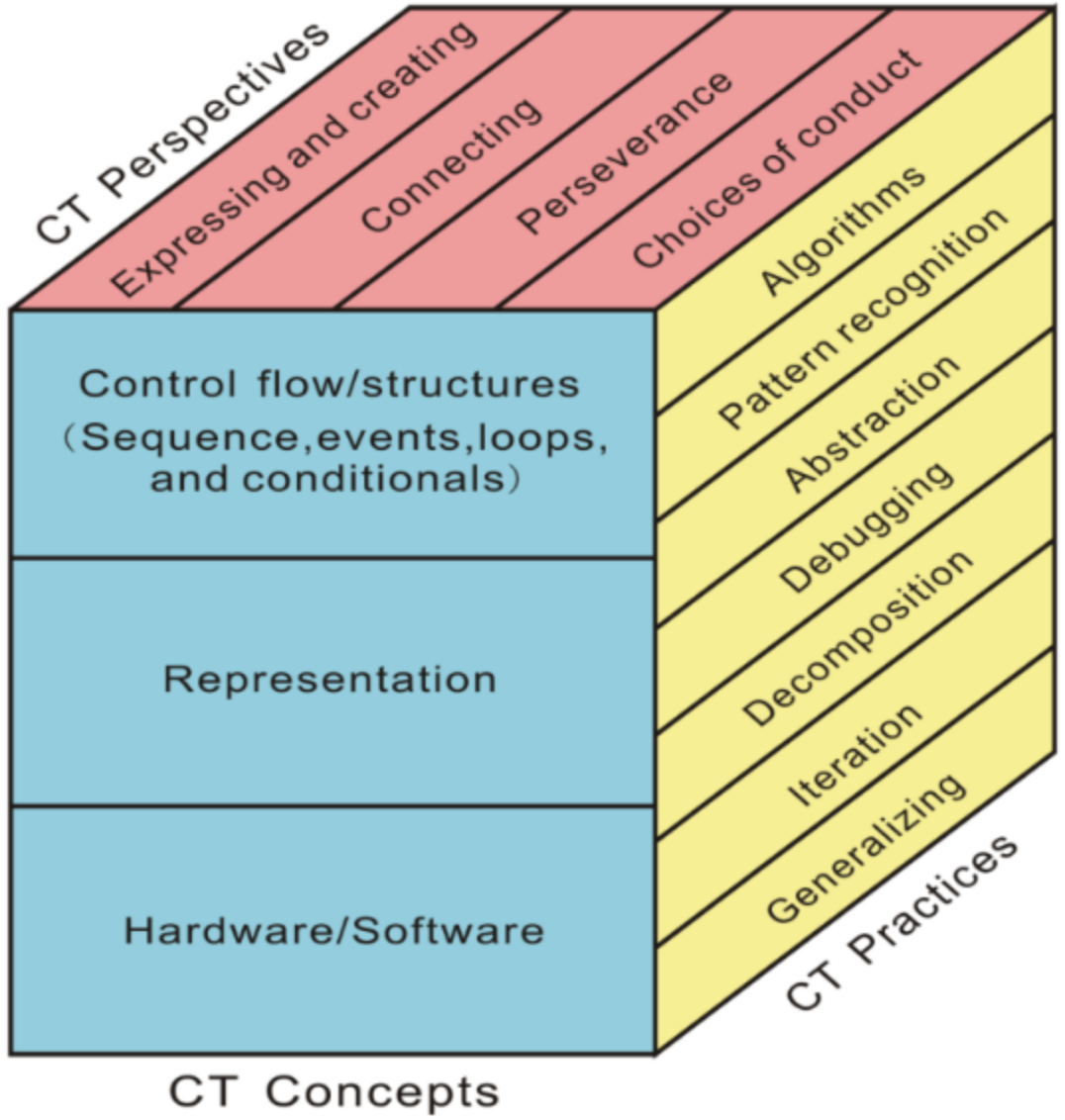
(2) using different levels of **abstraction** to solve problems, and

(3) thinking **algorithmically** to develop efficient solutions.



Sun, L., Hu, L., Zhou, D., Yang, W., & Wang, X. (2020). STEM learning attitude predicts computational thinking skills among primary school students. *Journal of Computer Assisted Learning.* https://doi.org/10.1111/jcal.12493

CT Framework in Early Childhood: A Three-Dimensional Model



(Zeng, Yang, & Bautista, 2023)

The Early Childhood CT Framework

CT concepts	Description	CT practices	Description	CT perspectives	Description
Control flow/structures	The sequence in which instructions/commands are followed and executed (Bers, 2018) Control flow/structures in ECE include sequence, loops, events, and conditionals.	***Algorithms***	Designing a series of ordered commands to accomplish a task or reach a goal effectively (Bers, 2018)	***Expressing and creating***	Treating computation as a way to create and express ideas (Brennan & Resnick, 2012)
		Pattern recognition	Finding patterns or similar characteristics to simplify the solution (Hsu et al., 2018)	***Connecting***	Communicating and cooperating with others to accomplish a task or solve a problem together, and sharing works with others to get feedback (Brennan & Resnick, 2012)
		Abstraction	Exclude unnecessary or unneeded details when solving a problem (Lee et al., 2022)		
Representation	Symbols can represent concepts, actions, sounds, and more (Bers, 2018)	***Debugging***	Finding and fixing errors when solutions failed to function as expected (Wang et al., 2020)	***Perseverance***	Being persistent when encountering difficulties or failures, and treating failures as a natural process of achieving a goal (Wang et al., 2020)
		Decomposition	Breaking down a complex problem or system into smaller, easier-to-manage pieces (Wing, 2011)		
		Iteration	Repeating the design process to seek improvements until the ideal solution is found (Shute et al., 2017)	***Choices of conduct***	Conscious decision-making about one's behavior (Pugnali et al., 2017)
Hardware/ Software	The hardware follows the instructions set in the software to accomplish tasks as a system (Bers, 2018)	***Generalizing***	Transferring solutions used to solve specific problems to new contexts (ISTE, 2011)		

(Zeng, Yang, & Bautista, 2023)

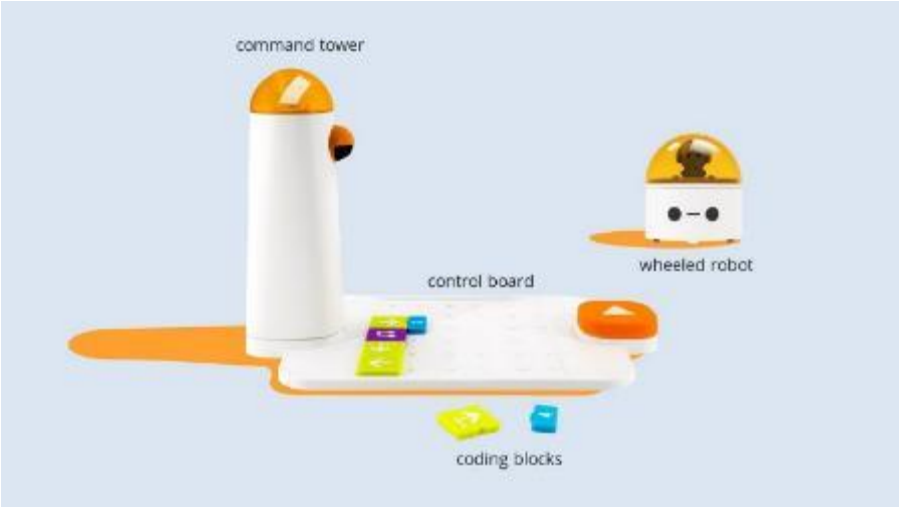
STUDY 1

- Robot Programming versus Block Play in Early Childhood Education: Effects on Computational Thinking, Sequencing Ability, and Self-Regulation

Yang, W., Ng, D. T. K., & Gao, H. (2022). Robot programming versus block play in early childhood education: Effects on computational thinking, sequencing ability, and self-regulation. *British Journal of Educational Technology*, *53*(6), 1817-1841.

Introduction

- Robot programming is increasingly used in early childhood education to introduce programming and computational thinking skills.
- However, little is known about the effectiveness of robot programming compared to traditional tools like blocks that are used in STEM activities.
- This study compared a robot programming intervention to a block play intervention in 4 kindergarten classes with 101 children.



Methodology

- Treatment (robot programming) versus comparison (block play) randomly assigned to 4 classes.
- Children assessed before and after 6 weeks on computational thinking (TechCheck), sequencing ability (Picture Sequencing Task), and self-regulation (HTKS).
- Robot programming group used Matatalab programmable robots.
- Block play group used marble run blocks.

Key Findings

Robot programming led to greater gains in sequencing ability compared to block play.

Self-regulation moderated gains - lower self-regulation children benefited more from robot programming.

Both interventions led to gains in outcomes over time.

Conclusions

Robot programming has benefits for sequencing ability and computational thinking compared to traditional block play.

Self-regulation and age moderate benefits, with lower functioning children and older children benefiting more.

Supports integrating innovative technology-enhanced learning in early childhood education.

Culturally Responsive Early Childhood Education

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- Being theme-based
- Integrating arts in (digital) learning
- Using storytelling based on multicultural literature
- Organizing exhibition for sharing

Rusk, N., Resnick, M., Berg, R., & Pezalla-Granlund, M. (2008). New pathways into robotics: Strategies for broadening participation. *Journal of Science Education and Technology, 17*(1), 59-69.

Culturally Responsive Robot Programming Experience

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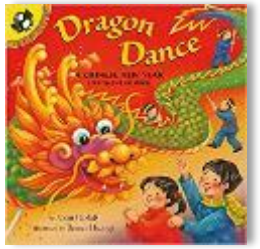
Select a **story** picture book



Design a warm-up **game**

Shared **reading**

Identify a **problem** from the story plot

Coding with technology

Unplugged **making**

Sharing solutions and prototypes

Story-Inspired Robot Programming (SIRP) Curriculum for Young Children in Hong Kong

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STUDY 2

- The impact of story-inspired programming on preschool children's computational thinking:A multi-group experiment

Yang, W., Ng, D. T. K., & Su, J. (2023). The impact of story-inspired programming on preschool children's computational thinking: A multi-group experiment. *Thinking Skills and Creativity*, *47*, 101218.

Introduction

- Computational thinking (CT) is important for developing creativity and problem-solving, but linking it to programming can be challenging for young children.

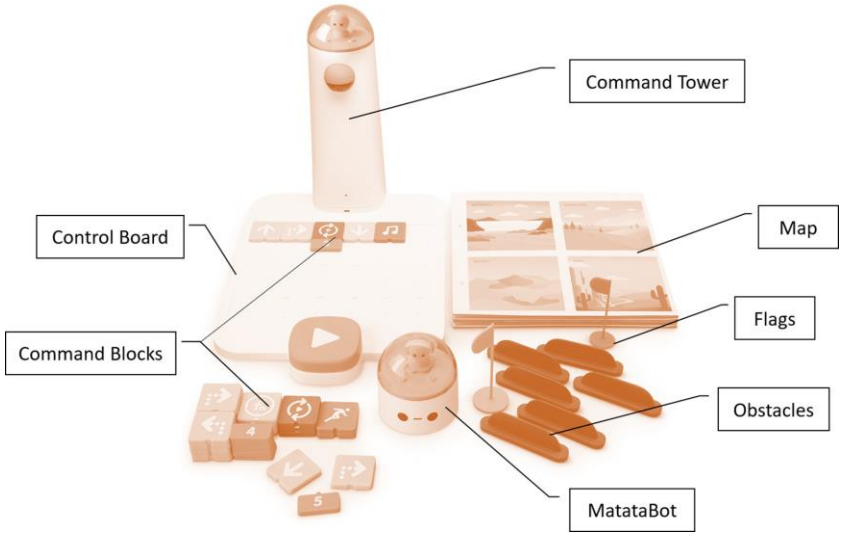
- Storytelling may help bridge the gap between programming and CT as a culturally responsive teaching strategy.

- This study evaluated story-inspired programming (SIP) interventions on 5-year-olds' CT skills.

https://matatalab.com/

Methodology

- 108 children participated in 9 weeks of CT learning via:
  - Story-Inspired Robot Programming (SIRP)
  - Story-Inspired Tablet Programming (SITP)
  - Unplugged CT Education (control)
- CT assessed before and after using TechCheck-K.



KEY FINDINGS

- SIRP and SITP improved CT scores compared to control group.
- No gender or SES differences in effectiveness of SIP interventions.
- Robot programming had greater benefits than tablet programming.

CONCLUSIONS

- Storytelling helped sustain child engagement and interest in programming activities.
- SIP interventions promoted preschoolers' CT skills more than unplugged CT education.
- Culturally responsive teaching like storytelling can make programming education more inclusive and meaningful.

STUDY 3

- Towards Inclusiveness and Sustainability of Robot Programming in Early Childhood: Child Engagement, Learning Outcomes and Teacher Perception

Yang, W., Luo, H., & Su, J. (2022). Towards inclusiveness and sustainability of robot programming in early childhood: Child engagement, learning outcomes and teacher perception. *British Journal of Educational Technology*, *53*(6), 1486-1510.

Introduction

- Screen-free robot programming (RP) allows teachers to implement age-appropriate integrated activities to promote computational thinking (CT) and other learning outcomes.
- However, very little is known about challenges of using RP to empower marginalized children.
- This study examined a Hong Kong Free Quality Kindergarten (FQK) situated in a low-income public housing estate to explore the affordances and challenges of RP in early childhood education (ECE).

Pedagogical procedure in the SIRP curriculum

Select a **story** picture book

Design a warm-up **game**

Shared **reading**

Identify a **problem** from the story plot

Coding with programmable robotics

Sharing solutions and clean-up

METHODOLOGY

- Mixed methods case study using quantitative (child assessments, video analysis) and qualitative (teacher interviews) data.
- 18 5-6 year old children from one FQK class participated.
- Children's CT and self-regulation were assessed before and after 6 weeks of SIRP curriculum.
- Child-robot interaction level (IL) was coded from videos to predict learning outcomes.
- Teachers were interviewed about implementing RP curriculum.

KEY FINDINGS

- Children's CT significantly improved after RP curriculum.
- Child-robot IL positively predicted improved self-regulation.
- Constraints:
  - teachers' limited technological pedagogical content knowledge,
  - disconnect between RP and school curriculum,
  - limited resources,
  - cultural barriers.

CONCLUSION

- RP curriculum can improve CT but careful implementation needed in underprivileged settings.
- Child engagement is key for maximizing learning outcomes.
- Systemic change needed to address constraints and make RP education inclusive and sustainable.

Empowering Young Children in the Digital Age

To empower our digital natives, ECE professionals must consider the following four aspects:

- Dedicated **space** with sufficient materials and tools (both traditional and digital);
- Upgraded **schedule** to provide sufficient time for young children to experience positive digital learning;
- **"Tech & Engineering"** in regular school-based curricula; and
- Provision of effective **training** and regular guidance for **teachers**.

Chinese Children's Learning Story...

New Book

Science, Technology, Engineering, Arts, and Mathematics (STEAM) Education in the Early Years: Achieving the Sustainable Development Goals

Edited By **Weipeng Yang, Sarika Kewalramani, Jyoti Senthil**

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